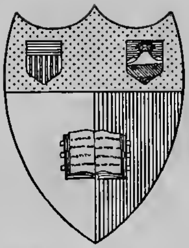
THE NATURAL THEOLOGY OF EVOLUTION

J. N. SHEARMAN.



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THE NATURAL THEOLOGY OF EVOLUTION

BY

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PREFACE

MOST persons who are disposed to be religious find it an easy thing to see the hand of God in the works of nature. To them it is pleasant and profitable to contemplate the world as God's handiwork, and they are disposed to offer the marks of design which it shows as a convincing proof of His existence. The attempt to present this proof in a clear and orderly way has given rise to Natural Theology, a study which, until quite recently, was in high repute and esteem.

It attained, perhaps, to its maximum of influence with the publication of Paley's *Natural Theology*, a remarkable work which put the argument from design in the plainest and clearest terms, and which was everywhere accepted as conclusive. It was accompanied and followed by many other works from which we may learn how highly Natural Theology was esteemed and how widely it was studied; of these the *Bridgwater Treatises* are, perhaps, the most famous. But this era of exceptional triumph and brilliancy did not last long. It may be said to have come to an end with the publication on the 24th of November, 1859, of Darwin's *Origin of Species*. As that book became well known the influence of Natural Theology declined. It was felt that the whole argument had lost its force, and that the appearance of plan and contrivance in Nature was fully and satisfactorily accounted for without any necessity for attributing it to conscious design. This is generally agreed to; the subject has dropped out of most men's thoughts; neither Paley's *Natural Theology* nor any similar work is ever included amongst the numerous reprints with which bookshops and bookstalls are flooded; it is hard to get them, and still harder to find anyone who has read them. Natural Theology is a subject everywhere ignored.

Now Darwin's *Origin of Species* is certainly a great and monumental work, and one which ought never to be forgotten. But to say that it does away with Natural Theology is a great mistake. It brings together a great number of reasons for believing that the existing species of plants and animals had their origin by a process of evolution. These reasons are so strong and so forcibly put that the doctrine of evolution is now universally received. It may be said to have passed out of the region of controversy, and for this all future generations will feel that Darwin is to be thanked and honoured. But besides proving the doctrine of evolution, Darwin tries to show how evolution has been brought about, and in this he is less successful. Not that he can be said to be wholly unsuccessful in his attempts to account for the origin of some species, but his doctrine of the Natural Selection of chance variations, while no doubt summing up events that have actually occurred, yet only accounts for the origin of some species, not of all, and does not at all account for the full and upward course of evolution.

There are two kinds of change conceivable in Nature; there is the change that implies progress, and the change that does not. Where there is change without progress, without increased complexity, without advance to a higher condition, the natural selection of chance variations may give rise to new species, but where there is real progress or advance to anything higher or more complex chance variations will not help, and any change that occurs is a proof of design. Thus Paley's argument has not really been refuted by Darwin's discovery. It only needs to be restated.

In restating the argument it has been thought well to begin in Part I with Paley's common-sense view, using Paley's very words where they will serve, and keeping in his company until we meet the objections arising out of the doctrine of evolution. Then it is shown that the same common-sense way of looking at things may be used here with the like success, and that it is possible in this way to see through the various attempts which have been made to account for evolution without ascribing it to design, and to discern their weakness. A chapter has been added on the theory put forth by M. Bergson in *Creative Evolution*, because it is necessary as far as possible to notice the different points of view from which attempts have been made to account for evolution, and because M. Bergson, like many another philosopher, is far more successful in refuting other doctrines than in establishing his own, and of his skill in this respect we shall take advantage afterwards. The reader who objects that this chapter goes a little beyond the title of Part I, and contains something pertaining rather to Philosophy than to common sense, must accept an apology. For there is very little in it that is more than plain common sense, and that little may be excused on account of its interest for the purpose of our argument. A note has been added giving some account of the discoveries of Mendel and de Vries, mainly because they tend to show that our supposition that there may be change without progress, and that new species may be formed which are on the same level as those from which they spring, is not merely an hypothesis invented to support an argument, but that such species are actually found to exist.

In the Second Part the argument is stated in a different way, not now from the standpoint of plain common sense, but so as to satisfy those who wish to search out the matter in a philosophical spirit. Here we ask what is meant by Chance and what may be expected from it, and show the true nature and proper proofs of Design. The omission of these questions was the great weakness in Paley's method of stating the argument. It was an omission which he, no doubt, did not at all notice, and which nobody else noticed while the reign of common sense lasted. But when the common-sense account of things was challenged and another way of looking at them was proposed, the only method by which Natural Theology could maintain itself was by a deeper and more accurate account of the ideas and beliefs on which it rested—an account which would not only support its argument, but apply a searching criticism to its opponents' theories. The absence of this account at a critical moment in the controversy was fatal. Natural selection and chance variation marched unopposed over positions that should have been disputed, and proclaimed the annexation of territory to which they had no right. It is put out now to recover lost ground and initiate a counter-attack.

There may be some who will find this section superfluous. Their grasp of those fundamental beliefs by which we live is so strong that nothing can loosen it. For them always and everywhere order means design, and no theories of Natural Selection or of any other kind can make it mean anything else. There are many signs that such persons are really to be found in considerable numbers, and that their influence and the objections which they raise are breaking up the forces which have inflicted a temporary defeat upon Natural Theology. For their sakes I have tried to elaborate the plainer form of the argument and to bring out its real force. But those who need the more exact discussion and those who are interested in it will not, I think, find it either difficult or abstruse.

I wish, however, here to protest as emphatically as I can that nobody has a right to say that he has felt the full force of this argument who has not actually performed the experiment recommended in the eleventh chapter. It may seem to be a trifling thing to do, and an objector may suppose that it is enough to read about it and dismiss it from his thoughts, but if he does this he will make a great mistake. In order to be thoroughly apprehended the argument must be applied to a present concrete instance or example, and such an example of a simple kind is suggested in the chapter referred to. Let him with that example before him ask the question—Why should I not get a regular orderly arrangement after a few trials, say five or six at the most, and why do I find it impossible to get, expect or hope for any such result ? and he will see that the only answer is that it is equally impossible that such a result should arise or that he should expect it. After that he may turn to the Third Part of this book and find every instance there brought forward full of light and interest.

The Third Part is really of great importance. No argument of this sort can be expected to be of much weight unless illustrated and enforced by good examples. These cases in point give many opportunities of repeating the chief parts of the argument with variations and explanations, and thus our reasoning is enforced by repetition and made clearer by illustration. We have also the advantage of showing that it is not merely an argument suspended in the air and influencing the imagination, but that it can come to earth and explain what it finds there. The illustrations are limited in number because nothing is brought forward or alleged as fact except upon the testimony of some reliable authority. Whenever it seems necessary the name of the authority relied on is mentioned. No doubt in the process of time, when our conception of Evolution has become clearer and our knowledge of details has become greater, many other examples will suggest themselves, of which some may be more striking and interesting than anything brought forward here. It is believed, however, that these will be found to suffice for the purpose for which they are intended.

The Fourth Part, which is short, briefly considers some objections and difficulties which on account of their general character stand rather outside the argument than within it. They are not likely to have much weight with anyone who has grasped our common-sense view or our further analysis of it. It is, however, satisfactory to be able to point out that they are of such a nature that we need not be disturbed by them.

The result of the whole argument is to show that the marks of design which the world exhibits and the testimony which it bears to its Creator, so far from being obscured or diminished by the discovery of the process of Evolution, become clearer, brighter and more convincing than they ever were before.

CONTENTS

PART I

A COMMON-SENSE ARGUMENT

CHAPTER I

PAGE
The Common-sense View 3

CHAPTER II

Paley's Common-sense View 11

CHAPTER III

The Implications of the Common-sense View . . 18

CHAPTER IV

The State of the Argument 26

CHAPTER V

The Question about Evolution 35

CHAPTER VI

What Chance Variation may do 46

CHAPTER VII

What Chance Variation cannot do 55

CHAPTER VIII

Creative Evolution 60

NOTE TO PART I

Mendelism and Mutationism 75

PART II

A MORE ABSTRACT OR PHILOSOPHICAL ARGUMENT

CHAPTER IX

PAGE

NECESSITY 89

CHAPTER X

CHANCE 95

CHAPTER XI

UNLIMITED CHANCE 101

NOTE TO CHAPTER XI

INFINITE NUMBERS 110

CHAPTER XII

THE CHANCE-PLUS-ORDER SERIES 113

CHAPTER XIII

NATURAL GROUPS AND SERIES 121

PART III

THE APPLICATION OF THE ARGUMENT

CHAPTER XIV

THE FERTILISATION OF THE CUCKOO-PINT AND OF THE ARISTOLOCHIA 131

CHAPTER XV

THE FERTILISATION OF ORCHIDS 142

CHAPTER XVI

THE EYE 152

CHAPTER XVII

PAGE
An Insectivorous Plant 182

CHAPTER XVIII

A Bird's Flight 195

CHAPTER XIX

The Pecten's Eye 219

CHAPTER XX

The Asymmetry of the Plaice 242

CHAPTER XXI

Instinct 251

PART IV

OBJECTIONS CONSIDERED

CHAPTER XXII

Some Objections 267

ILLUSTRATIONS

FIG. PAGE

1. The Common Arum or Cuckoo-pint 132
2. The Spike of the Cuckoo-pint 133
3. Section of Flower of Aristolochia 139
4. Orchis Mascula and Parts of same 145
5. Orchis Mascula, Pollinium as Removed on Pencil . 149
6. The scattering of Rays of Light 155
7. A Lens forming an Image 156
8. A Prism refracting a Ray of Light 157
9. Formation of Spectrum 158
10. A Compound Achromatic Lens 160
11. An Illustration of Spherical Aberration . . . 161
12. A Horizontal Section of the Eyeball 163
13. The Muscles of the Eye 167
14. Section of Retina 169
15. Drosera Rotundifolia (Sun-dew). Leaf viewed from above 188
16. Drosera Rotundifolia. Leaf viewed laterally . 189
17. Diagram showing how the Barbules cross . . 206
18. Part of a Pigeon's Wing highly magnified . . facing page 207
19. Diagram explanatory of preceding . . . . page 207
20. A Pigeon's Wing . . . . facing page 208
21. Pigeons Flying 212
22. Pecten's Eye 222
23. A young Plaice . . . . page 249

PART I

A COMMON-SENSE ARGUMENT

THE NATURAL THEOLOGY OF EVOLUTION

CHAPTER I

THE COMMON-SENSE VIEW

We must begin our exposition of the Natural Theology of Evolution by putting a question of the greatest practical importance. We are going to ask whether this world, in which we find ourselves and of which we are part, contains in its nature and working anything which would lead us to suppose that it had come from the hand of a conscious, intelligent Being with Whom we may possibly have personal dealing. The answer to such a question, if we can find it, will necessarily colour our whole outlook on life and will form a presupposition which we shall take with us into every other enquiry. But before we ask it we shall step aside to enquire how we are equipped for this investigation and what hope we have of prospering in it.

Now it is a point of no small importance that we are able to exist in the world, and not only to exist but to prosper beyond all other beings that are found in it, and that our prosperity depends, not like theirs upon instincts accommodated to some special way of living, but upon an exercise of reason which results in our understanding the nature of the things around us and knowing or observing their way of working. When we have settled how things work we act on the conclusions we have arrived at, and by the result of our action in each case the truth of our conclusion is tried and proved. When we are right we succeed and when we are wrong we fail, and this goes on through the whole time of every man's life and has gone on during the period, whatever it may be, covered by the existence of the human race as we know it. We have, therefore, the best of ground for saying that if our interpretation of nature were fundamentally erroneous it would long ago have caused the race of man to perish.

A single example will make this clear, and will, at the same time, enable us to see what our interpretation of Nature really involves. Let us suppose a primitive hunter to set out in the pursuit of game. His hunting is no mere sport, but the most serious of occupations, for his life and the lives of his family depend on his success. And his success depends on his knowledge of the nature of the animals which he pursues and his power of guessing what they are going to do as various incidents of the pursuit occur. The world is for him an examination hall and his whole life one long examination in which certain questions are put to him over and over again with the most tremendous penalties attached to erroneous answers. This examination has gone on for many generations, can we have any better test than it furnishes of the truth and accuracy of the beliefs which bring us through it successfully ?

Some part of the knowledge on which the primitive hunter relies is knowledge which belongs only to hunters and which is of no use to fishermen or farmers, but another part of it is common to all men and necessary for every occupation. What is peculiar to hunters is a personal possession to be acquired in one way only and that a way not open to any but hunters, but what is necessary for every occupation may be acquired by ways open to everyone, and is so simple, so fundamental and so important that many have supposed that it is not acquired at all, but belongs to the very constitution of the mind itself. To us, however, it is only so much knowledge. We are not now concerned with the ways we have of getting it.

When the hunter is stalking a timid animal his conduct is determined by his knowledge that the animal will be startled if he shows himself and will run away. But he also depends on his belief that the trees, stones and hillocks behind which he hides will not be startled and will not move but will remain absolutely inert. Now if he were wrong in his beliefs as to the nature of the animals he pursued his hunting would go wrong and he and his family would suffer, but if he were wrong in his beliefs as to the nature of sticks and stones and other common things all human action would go wrong and human life would be impossible. And therefore these common beliefs are the most important and the most severely tested of all. Yet these common beliefs are so intimately united to all our thoughts and actions that we hardly feel them to be beliefs at all. We do not seem to think them, but rather to see them and feel them and hear them. We do not expect a stone to move out of the way unless it is pulled or pushed or struck, but yet we do not feel that we are entertaining a belief as to the nature of the stone, we only feel that we are looking at an impediment. Thus our deepest and truest thoughts about common things are so familiar to us that they hardly look like thoughts, and we seem to see the inertness of the stone almost in the same way as we see the greenness of the grass. Only now and then, when we have to use these intimate beliefs in argument, do we bring them distinctly into consciousness as beliefs, and then we are apt to speak of them as common sense. When the hunter does not find his spear where he laid it down his common sense tells him that somebody has taken it away, when he finds meat roasting at a fire his common sense tells him that somebody put it there. But even in such cases the reasoning may take place so rapidly and spontaneously as not to be easily recognised for what it is.

With care, however, we may criticise our common-sense views of things, that is to say, we may come to see clearly what they are and how they can be usefully employed. To effect this we ask three questions: (1) What are the facts? (2) What are my common-sense beliefs? (3) How do these beliefs apply to the facts? The asking of these three questions marks the transition from common sense to Science, for Science always begins with criticised common sense and never indeed gets altogether away from it. Let us take as an example the common-sense belief which we all have, that no material thing will ever move itself or make any change in itself or, to put it in another way, that matter is inert. The facts to which we apply this belief are changes and alterations in things about us. Our belief is that none of these things have changed themselves. The application of our belief to the facts results in the conclusion that something else has brought about the change in every case, and so we say that every change or every event must have a cause. Thus our common-sense view of the nature of things when criticised and examined turns into the principle of causality, which dominates the whole course of scientific enquiry. We are then taking a reasonable course and one likely to be successful when at the beginning of Natural Theology we try to get at the common-sense view of things. What it has done for other enquiries it will also do for ours. And we shall now go on to ask whether the world shows any sign of having come from the hand of a conscious, intelligent Being, with the full conviction that the world we are examining is a world of which we have a genuine and well-proved knowledge.

Let me suppose that in walking over a level field I come across a number of small stones so arranged as to form the letters of my name; what has common sense to say about them? Most certainly it will say that they were so arranged by some intelligent being. I must take their arrangement to be an instance of design. When the first stone was put down the whole arrangement had been thought of, the result of putting down the stones was foreseen and action was so directed as to bring it about. Now if this decision depends on a principle of common sense as fixed and certain as the principle that sticks, stones and other common objects will not change unless some force is brought to bear on them it will give us a result as far-reaching and important. As the belief that material things are inert gives us the principle of causality according to which we hold that every event implies a preceding cause, so the belief that material forces are blind or without any self-contained principle of arrangement will give us the principle of design according to which we shall hold that order implies thought and foresight. Before, however, taking this as settled I must further examine my common sense so as to make sure that I have expressed its deliverance with accuracy.

Let me go back then again to the case I have put and ask whether I could not manage to believe that this arrangement of pebbles on the grass by which my name is expressed came about by chance, meaning by chance nothing more than the action of force without design. If a cartload of stones had been brought this way these stones might have been shaken out by the jolting of the cart as it passed; why then might they not have fallen as they now lie? The only answer is that if they had so fallen out there would have been no design to guide them, their arrangement would have been a chance arrangement and could not, therefore, have been an orderly arrangement such as this. "But then," I go on to reason with myself, "the stones, however they got here, must have some arrangement, whether orderly or disorderly, this is only one out of all possible arrangements, could they not have fallen thus as well as in any other way?" I find, however, that the verdict of my common sense is not changed. This orderly arrangement did not come by chance. Yet I remind myself again that the question is not whether this arrangement might be repeated if the cart were to pass by again, nor yet whether I might find this or any other arrangement which was before expected or wished for. Let these ideas be put aside as impossibilities. Let us duly consider the incalculable infinities of positions in which the stones might lie, and let us only say, on the other side, that they must lie in some position. May we not ask Why should they not lie in this position as well as in any other, or if not in this precise position in some position which would present an equally striking example of order? The only possible answer is that I cannot help myself. I must hold the common-sense principle that order implies design, and when I see this or any other instance of order I am compelled to believe that it came about by design and not by chance.

For so far the course of my reasoning has been very clear and simple, and the conclusion will not be disputed by anyone. Confining my view to the ordinary things with which I am well acquainted, the things which I see and handle from day to day, whether they are things as found in nature or as manufactured for human use, provided only that they are things without life, I say that they are inert or have no power of spontaneous motion, and that the forces which operate in them and through them are blind—that is they have no power of self-direction or arrangement. Consequently whenever I come across order or regular arrangement I ascribe it to design and say that it is the work of mind as involving foresight and purpose. Thus if I find the furniture in a room all in disorder I say that the positions of the chairs and tables are due to chance; but if there is any regular order or arrangement I cannot help ascribing it to design, and the same holds good of all other instances of orderly arrangement amongst things with which I am acquainted, such as trees or plants growing in regular rows, flower-beds having regular shapes, paths having a definite form and direction, walls, hedges, and ditches having a regular and orderly shape and formation. No one can possibly doubt that in all such cases the regularity and order which I find is due to design and could not by any possibility come about by chance, and if any such instance of order and regularity were discovered in the depths of a primeval forest, where it was supposed that the foot of man had never come before, there would not be the slightest hesitation in coming to the conclusion that this also was due to the design of some intelligent being.

May I, then, carry my argument one step farther and apply it to the instances of order and regularity which I find in nature ? May I say that as the regular shape of the flower-bed proves the existence of an intelligent being to whom it is due, so likewise does the regular shape of the flower which grows in it ? May I say that as the regular and orderly arrangement of a number of pebbles forming the letters of my name, if I found them so displayed on the sea beach, would be an infallible proof of design, so is the regular and orderly arrangement and disposition of the sands on which they lie, which are sorted according to their degrees of fineness and arranged so as to have a regular sloping surface ? The matter is the same inert matter with which I have to deal every day and I cannot attribute to it any other properties or any power of spontaneous movement in the flower or in the strand which it does not possess in other positions. It is moved into its position by such ordinary physical forces as are capable of imparting motion to matter, how can I suppose these forces to be capable of producing order and regularity apart from mind here if they are not able to do it everywhere ? Must I not come to the conclusion that in every case in which it is found order is the result of design ?

I believe that if the final decision of the human mind can be disentangled from everything that may obscure its application or conceal its force, that will be its purport, but many things may cause confusion of thought and become obstacles to the legitimate application of the most certain truths, and therefore we cannot at one glance see design in the sands or the flower. The regular shape of the flower, the orderly disposition of the sands, are not due to a single action which can be looked on as a whole and which has but few steps, but are due to the general course of nature which works as an immensely complicated machine carrying on a process which extends over a vast tract of time, and in that working it is supposed that chance (that is the action of force apart from design or intention) might have the power of doing what we are unable to suppose it to do in any action or movement that can be regarded as a whole. If that is not accepted yet the mind may so lose itself in the consideration of an almost infinitely complicated process extending over an almost endless period of time as never to arrive at any conclusion at all. Thus it becomes necessary to consider the course of nature as a continued process, and to ask whether an examination of the common-sense view of it will disclose the fundamental principles of belief by which all such questions as these must be decided.

CHAPTER II

PALEY'S COMMON-SENSE VIEW

We have then to consider not things at rest but things in motion. We have to look for possible evidences of design not in mere order or regularity of arrangement, but in the orderly and regular performance of function. And certainly at first sight it would appear that whatever testimony an orderly arrangement might bear to the existence of design, the testimony of orderly functioning must be immensely stronger and more impressive. There is as much order and arrangement in the parts of a machine when at rest as in any of the cases of orderly arrangement which we have already considered, and there are besides the facts that the parts are so compacted and joined together that they move on one another and produce a certain result, and that they are so fitted to the circumstances in which they are placed as to respond to these circumstances, affecting and being affected in an orderly way and to a definite end. It is therefore with some surprise that we find that it is in this, which should be the strongest part of our argument, that weakness is supposed to be discovered. The proof of design, which seemed irresistible when we considered the flower simply as a regular arrangement of parts put together once for all, is thought to lose all its force when the flower is considered as a machine supplying the bee with honey, in return for which it is helped by the bee over a difficult part of its life, after which it proceeds to form a seed out of which will come another plant bearing a similar flower. We have, then, to enquire what is the new element introduced into the argument at this point to produce so strange a result. We shall, therefore, in the first place carefully examine the common-sense view of a machine or organism as an evidence of design and bring out all that it contains. In doing this we shall have to ask whether there is any difference for the purpose of our enquiry between a machine which is a mere machine and one which is also an animal or vegetable organism, but we must, it is evident, begin with the mere machine, and we cannot therefore do better than to follow the line of enquiry pursued by Paley in his justly celebrated work.

Paley supposes himself to find a watch in crossing a heath and asks what account could possibly be given of it in contrast to what might be said about a stone if it were found in the same place. As Geology had not yet become a commonly known science when Paley wrote, the stone was to him an object in which no particular structure could be discerned and to which no history could be ascribed, and, therefore, all that he was able to say about it was that for aught he could tell it might have lain where he found it since the world came into being. If we know more about the stone than Paley did, so that to us the contrast between it and the watch is not so great as it was for him, that does not affect the validity of the argument, which in no way depends on what he failed to see in the stone, but rests altogether on what he did see in the watch. And this is what he saw :—

When we come to inspect the watch we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose, e.g. that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day ; that if the different parts had been differently shaped from what they are of a different size from what they are or placed after any other manner or in any other order than that in which they are placed either no motion at all would have been carried on in the machine or none which would have answered the use that is now served by it. To reckon up a few of the plainest of these parts and of their offices all tending to one result. We see a cylindrical box containing a coiled elastic spring which by its endeavour to relax itself turns round the box. We next observe a flexible chain (artificially wrought for the sake of flexure) communicating the action of the spring from the box to the fusee. We then find a series of wheels the teeth of which catch in and apply to each other, conducting the motion from the fusee to the balance and from the balance to the pointer, and at the same time by the size and shape of those wheels so regulating that motion as to terminate in causing an index by an equable and measured progression to pass over a given space in a given time. We take notice that the wheels are made of brass to keep them from rust, the springs of steel, no other metal being so elastic, that over the face of the watch there is placed a glass, a material employed in no other part of the work, but in the room of which if there had been any other than a transparent substance the hour could not be seen without opening the case. This mechanism being observed (it requires indeed an examination of the instrument and perhaps some previous knowledge of the subject to perceive and understand it, but being once, as we have said, observed and understood) the inference, we think, is inevitable, that the watch must have had a maker, that there must have existed at some time and at some place or other an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its structure and designed its use. The argument, in fact, is precisely the same as that which we have considered in the first chapter, except in so far as the greater complication introduced by the consideration of parts in motion and of the way in which their motion answers certain ends puts the possibility of such an arrangement resulting from chance still farther out of sight, and so makes the instance chosen still more impressive. But we have yet to consider the points in which an organism differs from a mere machine and to ask common sense for its verdict upon them.

I. It would not, I apprehend, weaken the conclusion that we had never seen a watch made that we had never known an artist capable of making one, that we were altogether incapable of executing such a piece of workmanship ourselves or of understanding in what manner it was performed, all this being no more than what is true of some exquisite remains of ancient art, of lost arts and to the generality of mankind of the more curious productions of modern manufacture. Does one man in a million know how oval frames are turned ? Ignorance of this kind exalts our opinion of the unseen and unknown artist's skill if he be unseen and unknown, but raises no doubt in our mind of the existence and agency of such an artist at some former time and in some place or other. Nor can I perceive that it varies at all the inference whether the question arise concerning a human agent, or concerning an agent of a different species, or an agent possessing in some respects a different nature. For the inference is that the work proceeds from an agent exercising foresight, purpose and skill. Whether these qualities must be supposed to exist in such a degree as human beings are capable of or in a much greater degree is another question which does not at all enter into the present argument.

II. Neither, secondly, would it invalidate our conclusion that the watch sometimes went wrong, or that it seldom went exactly right. The purpose of the machinery, the design and the designer might be evident, and in the case supposed would be evident in whatever way we accounted for the irregularity of the movement, or whether we could account for it or not. It is not necessary that a machine be perfect in order to show with what design it was made, still less necessary where the only question is whether it were made with any design at all.

III. Nor, thirdly, would it bring any uncertainty into the argument if there were a few parts of the watch concerning which we could not discover, or had not yet discovered in what manner they conduced to the general effect, or even some parts concerning which we could not ascertain whether they conduced to that effect in any manner whatever. For as to the first branch of the case, if by the loss or disorder or decay of the parts in question the movement of the watch were found, in fact, to be stopped, or disturbed, or retarded no doubt would remain in our minds as to the utility or intention of these parts, although we should be unable to investigate the manner according to which, or the connection by which the ultimate effect depended upon their action or assistance, and the more complex is the machine the more likely is this obscurity to arise. Then, as to the second thing supposed, namely, that there were parts which might be spared without prejudice to the movement of the watch and that we had proved this by experiment, these superfluous parts, even if we were completely assured that they were such, would not vacate the reasoning which we had instituted concerning other parts. The indication of contrivance remains with respect to them nearly as it was before.

IV. Nor, fourthly, would any man in his senses think the existence of the watch with its various machinery accounted for by being told that it was one out of the possible combinations of material forms, that whatever he found in the place where he found the watch must have contained some internal configuration or other, and that this configuration might be the structure now exhibited, viz. of the works of a watch as well as a different structure.

Thus, by a careful consideration of the thoughts which must inevitably arise in the mind when such a regular piece of machinery as a watch has been found, by putting cases to myself and asking myself questions, I come to see that I am shut up to the belief that it was produced by some conscious intelligent being, who foresaw the result which would follow from certain actions and movements, and so directed them as to produce the orderly arrangement of parts which is observed to exist. Whatever name may be given to the process of producing the watch must be so interpreted as to be consistent with the existence of such a designer and producer. If it is said to be produced according to law it must be a law which requires the action of intelligence and design, if it is ascribed to a principle of order the principle must be the intelligent working of a designer, if it is accounted for in any other way the account must be so construed as not to contradict the conclusion now arrived at.

But just at this point some impatient person is sure to interrupt the argument with an objection. " What has been laid down is true and indisputable, but it only applies to works of art. When we come to the works of Nature all is changed. They are produced in a manner wholly different from machines such as human beings can make, and the same principles will not apply to them. Why, then, waste time in considering cases which are so different from the real case on which judgment must finally be passed ? " The reason for considering these cases is that all material things have the same nature and all reasonable beings have the same kind of reason. That all material things have the same nature is the postulate on which rests all the action by which life is preserved and all the knowledge which science has accumulated. That there is only one kind of reason is the postulate on which all reasoning depends. It is therefore of the first importance to learn how a reasonable being deals with inanimate objects and what he necessarily believes about them. And the best and wisest method of enquiry is to begin with the plainest and simplest case that can be found, and gradually to work outwards, thus ascertaining how far the principles which rule in the simplest case will carry and discovering where disputable territory begins, or perhaps it were better to say ascertaining whether there is any disputable territory at all.

CHAPTER III

THE IMPLICATIONS OF THE COMMON-SENSE VIEW

We have now to consider whether we can take one step farther and find something contained or implied in the view which we cannot avoid taking of the origin of the supposed watch, which will help us when we come to apply our argument to the case of animal and vegetable organisms as found in nature. This step was taken by Paley with perfect success. It was never doubted in his own day that his argument was convincing, and if it is doubted in our day it is not that any weakness can be found in his reasoning so far as it goes, but that it is alleged that it does not go far enough. Besides the one step which he took there was another step to be taken of which he knew nothing, and here it is that the argument is said to fail. We must deal with that other step when we come to it, but our wisest course is to go with Paley as far as he can take us and to attempt the final stage in the argument with the full conviction that there is no weakness in what has gone before.

Suppose, he goes on, in the next place that the person who found the watch should after some time discover that in addition to all the properties which he had hitherto observed in it, it possessed the unexpected property of producing in the course of its movement another watch like itself (the thing is conceivable), that it contained within it a mechanism or system of parts, a mould, for instance, or a complex adjustment of lathes, files and other tools evidently and separately calculated for this purpose, let us enquire what effect such a discovery ought to have upon his former conclusion.

I. The first effect would be to increase his admiration of the contrivance and his conviction of the consummate skill of the contriver. Whether he regarded the object of the contrivance, the distinct apparatus, the intricate, yet in many parts intelligible mechanism by which it was carried on he would perceive in this new observation nothing but an additional reason for doing what he had already done—for referring the construction of the watch to design and to supreme art. If that construction *without* this property, or which is the same thing, before this property had been noticed, proved intention and art to have been employed about it still more strong would the proof appear when he came to the knowledge of this further property, the crown and perfection of all the rest.

II. He would reflect that though the watch before him were *in some sense* the maker of the watch which was fabricated in the course of its movements, yet it was in a very different sense from that in which a carpenter, for instance, is the maker of a chair; the author of its contrivance, the cause of the relation of the parts to their use. With respect to these the first watch was no cause at all to the second; in no such sense as this was it the author of the constitution and order either of the parts which the new watch contained or of the parts by the aid and instrumentality of which it was produced. We might possibly say but with great latitude of expression that a stream of water ground corn, but no latitude of expression would allow us to say, no stretch of conjecture would lead us to think, that the stream of water built the mill, though it were too ancient for us to know who the builder was. What the stream of water does in the affair is neither more nor less than this: by the application of an unintelligent impulse to a mechanism previously arranged—arranged independently of it, and arranged by intelligence, an effect is produced, viz. the corn is ground. But the effect results from the arrangement. The force of the stream cannot be said to be the cause or author of the effect, still less of the arrangement. Understanding and plan in the formation of the mill were not the less necessary for any share which the water has in grinding the corn, yet is this share the same which the watch would have contributed to the production of the new watch upon the supposition assumed in the last section. Therefore

III. Though it be now no longer probable that the individual watch which our observer had found was made immediately by the hand of an artificer, yet doth not this alteration in any wise affect the inference that an artificer had been originally employed and concerned in the production. The argument from design remains as it was. Marks of design and contrivance are no more accounted for now than they were before. In the same thing we may ask for the cause of different properties. We may ask for the cause of the colour of a body, of its hardness, of its heat, and these causes may all be different. We are now asking for the cause of that subserviency to a use, that relation to an end which we have remarked in the watch before us. No answer is given to this question by telling us that a preceding watch produced it. There cannot be a design without a designer, contrivance without a contriver, order without choice, arrangement without anything capable of arranging, subserviency, and relation to a purpose without that which could intend a purpose, means suitable to an end and executing their office in accomplishing that end without the end having been contemplated or the means accommodated to it. Arrangement, disposition of parts, subserviency of means to an end, relation of instruments to a use imply the presence of intelligence and mind. No one, therefore, can rationally believe that the insensible inanimate watch from which the watch before us issued was the proper cause of the mechanism we so much admire in it—could be truly said to have constructed the instrument, disposed its parts, assigned their office, determined their order, action, and mutual dependency ; combined their several motions into one result, and that also a result connected with the utilities of other beings. All these properties, therefore, are as much unaccounted for as they were before.

Nobody in Paley's time was able to resist this reasoning, and it is impossible to see how anyone can resist it now ; but here we come to the farthest point at which we can reckon on anything like a general agreement. It is at the next step that the argument is supposed to break down. Paley supposed his watch to have been produced from another watch not less highly organised than itself, and he took it for granted that however far back the series might be supposed to extend the individuals would all be similar, and that whenever it began, if a beginning were granted, it would begin with just such a watch as the latest member of the series suddenly somehow or other brought into existence. This supposition corresponded to the view of nature entertained by all men in his day, and if his opponents tried to argue that plants and animals came into existence by chance they would have felt themselves compelled to maintain that the organisms so produced by chance were as elaborate and as perfect as any that are now to be seen. This accounts for the impression which his argument made. Before we ask whether there is any real weight in the objections which have been made to it let us follow it to the end as it came from his hand, taking his view of nature for granted. We shall find it worth our while to do this because the discussion has an historical interest, and also because it is a part of the enquiry into what is really involved in those ideas of the nature of things of which we can never get rid. The argument continues thus :—

IV. Nor is there anything gained by running the difficulty farther back, i.e. by supposing the watch before us to have been produced from another watch, and that from a former, and so on indefinitely. Our going back ever so far brings us no nearer to the least degree of satisfaction upon the subject. Contrivance is still unaccounted for. We still want a contriver. A designing mind is neither supplied by this supposition nor dispensed with. If the difficulty were diminished the farther we went back by going back indefinitely, we might exhaust it. And this is the only case to which this sort of reasoning applies. Where there is a tendency or as we increase the number of terms a continual approach towards a limit *there* by supposing the number of terms to be what is called infinite we may conceive the limit to be attained, but where there is no such tendency or approach nothing is effected by lengthening the series. There is no difference as to the point in question (whatever there may be as to many points) between one series and another, between a series which is finite and a series which is infinite. A chain composed of an infinite number of links can no more support itself than a chain composed of a finite number of links. And of this we are assured (though we never *can* have tried the experiment) because by increasing the number of links from ten, for instance, to a hundred, from a hundred to a thousand, etc., we make not the smallest approach, we observe not the smallest tendency, towards self-support. There is no difference in this respect (yet there may be a great difference in several respects) between a chain of a greater or less length, between one chain and another, between one that is finite and one that is infinite. This very much resembles the case before us. The machine which we are inspecting demonstrates, by its construction, contrivance and design. Contrivance must have had a contriver, design a designer, whether the machine immediately proceeded from another machine or not. That circumstance alters not the case. That other machine may, in like manner, have proceeded from a former machine; nor does that alter the case, the contrivance must have had a contriver. That former one from one preceding it: no alteration, a contriver is still necessary. No tendency is perceived, no approach towards a diminution of this necessity. It is the same with any and every succession of these machines; a succession of ten, of a hundred, of a thousand; with one series as with another; a series which is finite as with a series which is infinite. In whatever other respects they may differ, in this they do not. In all equally contrivance and design are unaccounted for.

The question is not simply, How came the first watch into existence? Which question it may be pretended is done away by supposing the series of watches thus produced from one another to have been infinite and consequently to have had no such *first* for which it was necessary to provide a cause. This, perhaps, would have been nearly the state of the question if nothing had been before us but an unorganised, unmechanised substance without mark or indication of contrivance. It might be difficult to show that such substance could not have existed from eternity either in succession (if it were possible, which I think it is not, for unorganised bodies to spring from one another) or by individual perpetuity. But that is not the question now. To suppose it to be so is to suppose that it made no difference whether he had found a watch or a stone. As it is the metaphysics of the question have no place, for in the watch which we are examining are seen contrivance, design, an end, a purpose, means for the end, adaptation to the purpose. And the question which irresistibly presses upon our thoughts is, Whence this contrivance and design? The thing required is the intending mind, the adapted hand, the intelligence by which that hand was directed. This question, this demand, is not shaken off by increasing a number or succession of substances destitute of these properties, nor the more by increasing that number to infinity. If it be said that upon the supposition of one watch being produced from another in the course of that other's movements, and by means of the mechanism within it we have a cause for the watch in my hand, viz. the watch from which it proceeded—I deny that for the design, the contrivance, the suitableness of means to an end, the adaptation of instruments to a use (all which we discover in the watch) we have any cause whatever. It is in vain, therefore, to assign a series of such causes, or to allege that a series may be carried back to infinity, for I do not admit that we have yet any cause at all for the phenomena, still less any series of causes, either finite or infinite. Here is contrivance but no contriver; proofs of design but no designer.

V. Our observer would further also reflect that the maker of the watch before him was in truth and reality the maker of every watch produced from it: there being no difference (except that the latter manifests more exquisite skill) between the making of a watch with his own hands, by the mediation of files, lathes, chisels, etc., and the disposing, fixing and inserting of these instruments, or others equivalent to them, in the body of the watch already made in such a manner as to form a new watch in the course of the movements which he had given to the old one. It is only working by one set of tools instead of another.

The conclusion which the *first* examination of the watch, of its works, construction and movement suggested was that it must have had for the author of that construction an artist who understood its mechanism and designed its use. This conclusion is invincible. A *second* examination presents us with a new discovery. The watch is found in the course of its movement to produce another watch similar to itself, and not only so but we perceive in it a system or organisation separately calculated for that purpose. What effect would this discovery have, or ought it to have, upon our former inference? What, as hath already been said, but to increase beyond measure our admiration of the skill which had been employed in the formation of such a machine? Or shall it, instead of this, all at once turn us round to an opposite conclusion, viz. that no art or skill whatever has been concerned in the business, although all other evidences of art and skill remain as they were and this last and supreme piece of art be now added to the rest? Can this be maintained without absurdity? Yet this is atheism.

CHAPTER IV

THE STATE OF THE ARGUMENT

THE words which we have quoted from Paley at the close of the last chapter, "This is Atheism," mean that atheism, or the denial that the world is due to the design of an intelligent contriver, involves the very same sort of absurdity as would the denial that the supposed watch which for so far we have been considering was due to an intelligent designer and maker. This statement he proceeds to prove and illustrate by adducing instances of natural organisms fulfilling definite ends and producing a constant and useful result by means of machinery more complicated and wonderful than that of any watch. He begins with the eye as found in man, in birds and in fishes, and points out the many striking instances of order and adaptation of the fitting of means to produce an end of complicated mechanism working smoothly which this organ in its various forms displays. And from this he proceeds to notice a great number of other instances of the same kind to be found in the animal and vegetable kingdoms. The description of these cases, and the author's comments upon each, form the greater part of his work on *Natural Theology*. And the appetite for such illustrations excited by the argument which we have just considered was so great that he was never accused of adducing too many of them. On the contrary, supplements to his work were brought out containing many more, and great interest was felt in such works as the *Bridgwater Treatises*, in which instances of design in nature were expounded at great length.

I think it was a true instinct which led to this wealth of illustration, for when we are trying to get at the primitive and fundamental beliefs of the human mind, and that is what the present argument aims at, we succeed much better by the way of concrete illustration than by way of merely abstract thought. We have certain fundamental beliefs on which all our knowledge depends and by which all our actions are guided, but it is not natural with us to state them in abstract form. We are always applying these beliefs to concrete cases, and we know well how they work in concrete cases, but in abstract form we often find it hard to recognise them and sometimes almost impossible to follow their working. And, therefore, when the abstract statement is necessary it will always be more clear and intelligible if taken in connection with some concrete illustration. And the same illustration will make an argument in abstract terms much more forcible and convincing. I feel, for my own part, that the argument against the chance production of a watch is by many degrees more clear and telling when I hold my watch in my hand and look at it than when I put it into my pocket and think of watches in general in an abstract way. And I am sure that there is nobody who would not feel it much more difficult to think that a dog or a cat had been produced by chance while actually watching his dog scampering before him or stroking his cat admiring the softness of her fur and listening to her contented purring than when thinking of dogs and cats in general, with no animal of either kind within sight or hearing. We are, however, shut out from these pleasant paths for the present by the course which the controversy takes in our own day.

For what has happened is this: to the two examinations of the watch which are mentioned by Paley in the summary of the argument quoted at the close of the last chapter, there has been added a third. Upon the *first* examination we consider the watch as an arrangement of parts working together as a means to bring about a certain end. Upon the *second* examination we consider the watch as the product of another just like itself and think of the series as extending backwards indefinitely in time. But now we make a *third* examination and find that on following the series backwards the watches by slow degrees become less and less complex in construction, until when we have got back as far as we can go we discover nothing more complex than a revolving barrel. We have now a new property pertaining to the series of watches. As one produces another there is an increase in complexity, accompanied by an increased power of producing useful results ; in other words, we find that the series of watches, or rather of machines, which, beginning with something very simple, turn out to be watches in the end, gives us an instance of Evolution, and we ask what effect that should have upon our argument. Must we now say that while the watch as a machine produced at one time must necessarily be due to design, yet the watch when regarded as built up in the course of a lengthened period by slow and gradual changes may reasonably be taken to be the result of chance, meaning by chance the action of force apart from thought or purpose ?

There are several ways of understanding this question, and we must take them separately. And first, we shall suppose that what is intended is merely that the process of constructing the watch is seen to be one that extended over a long time and was divided into a great number of steps, each by itself being an extremely small part of the whole. If this is what is meant by evolution it is plain that it neither adds anything to our argument nor takes anything from it. The process of constructing a watch is not altered in its nature because it is divided into steps between each of which and the next a certain time is allowed to elapse. If mind and purpose are required to account for the whole when regarded as one event, they are no less required to account for it when considered to be the final result of myriads of events. Indeed they are required in each case for the same reason. The construction of a watch may be regarded as one event, but it is an event in which many parts can be discerned—an event which is composed of many smaller events—and the co-ordination of these. Their combination into one total having one finite result demands the presence of purpose and will, and demands it with equal urgency whether they come together at one time or are spread out and come one after another during a long period of time. Why, we ask, do all the little impulses, the small movements, the slight exertions of force which go to the making of a watch combine together to one result so that they help one another instead of hindering, they tend in one direction instead of many, they make something instead of destroying it ? And we say that the only possible reason why they combine is that they are directed and controlled by mind having foresight and purpose. And the question and the answer are equally inevitable whether the parts of the total event are collected together or spread out far apart. The mere passage of time is no real substitute for the action of mind, nor is the evidence for design and purpose altered by considering the total event to be divided into innumerable small portions.

Would anything which requires the action of mind require it at all the less if we understood that it came about bit by bit and took a long time to accomplish ? If I am struck by finding a number of pebbles so disposed as to form the letters of my name, and if I determine that this arrangement shows design and must be due to a conscious intelligence, must I change my view if I am told that the stones came into their places one by one and that two never came in the same week ? Is it not evident that this spreading out or dividing of an event makes no difference at all ? Whatever requires the presence of mind if it comes about in one way must equally require it when it comes about in the other way.

If design is looked upon as the building up or construction of order it attaches to every part of the process of construction as well as to the whole or final result. If it were not shown in the parts it would not be shown in the whole. If there were not design but only chance in each infinitesimal portion it could not suddenly turn from chance to design when all were added together. And therefore to take any small or infinitesimal part of the process by itself is not the way to diminish the force or efficacy of the argument which infers the action of mind from the presence of order. It may be difficult to perceive the curvature in a very small arc of a circle, yet it is undoubtedly there. I may find it hard to distinguish the arc from a straight line, but I know that it is different and I do not imagine that a number of straight lines would acquire a curvature merely by being put together and would so form a circle. And if I take an arc so long that the curve is perceptible it is seen to be as truly a curve as the circle taken as a whole. In like manner there may be changes in the course of evolution so small as to be imperceptible to me and additions so trifling and obscure that I cannot tell whether there is any increase of order and adaptation or not, but so surely as I take in a space sufficient to show some increase in order, some new adaptation, I find the same necessity for supposing the action of mind, the presence of purpose and design as when I consider the full result of the complete evolution. If evolution is regarded merely as splitting up the process and spreading it out there is nothing in it which can in any way affect the argument.

But so to regard evolution is to take it simply as a fact without asking for any cause or explanation. It is to describe it altogether from the outside without trying to get at its real nature. It is quite easy to see why such a way of looking at it throws no light on an argument which deals altogether with the question What sort of cause could bring this result about ? When we try to get a clearer view of the nature of evolution we find that it is a name for the common characteristic of several kinds of process, and these we must try to examine one by one.

The common characteristic is that the machine or construction or whatever is evolved appears at first in a very imperfect form and gradually approximates to the final result. There is a series of steps by which the end is reached ; there is a progress by degrees towards something which has the appearance of being aimed at or intended.

When any one person dwells much upon one idea and tries to think it out and understand it, or to embody it in some visible and tangible form, the products of his thought and activity will exhibit such a series. If he tries to think out some general or abstract idea, a series of essays in which he recorded his successive attempts would show the evolution of his thought. If he were trying to represent his thought in a picture, a series of tentative pictures or sketches would exhibit a like evolution. If he were trying to invent a new machine for a certain purpose, he might produce a series of failures or partial successes which would show the evolution of the perfect machine. If he were trying to breed a flower or an animal which would have certain peculiarities of form or colour, he would certainly pass through a like series of results on his way to success. In all these cases we would have the genuine characteristics of evolution, but proceeding altogether from purpose and design ; we would have them as the result of the conscious action of mind. This alone is enough to show that evolution does not of itself in any way exclude the presence and action of mind.

We get other series exhibiting an evolutionary progress from the combined action of many minds, resulting in the growth of arts and crafts and in the continued improvement of domestic animals, cultivated plants and useful machines and instruments. Here the minds of many are exercised on the one series and they are all animated by a common purpose. This is not due to any foresight of the final result, which is often of a kind that could not possibly be anticipated by the first workers, but consists in a determination to advance in a certain direction. If the advance goes on beyond anything that was dreamed of at first, yet there is no change in the purpose of those who are carrying on the work, they still desire improvement, and the same sort of improvement which was sought for at the beginning. Here we have the evolution of a common purpose.

Such an evolution often leaves traces behind it, these being either some of its actual products at various stages which, being of a permanent character, endure and attract attention during later periods, or else records of what was said and done or made by which the life of former times, with its apparatus and surroundings, are known to us. These traces of evolution are very similar to the traces of the evolution of plants and animals preserved as fossils in the rocks. They show the same regular progress, the same increasing complexity, the same appearance of a progress by trial and failure, by rejecting what fails and trying again until something better appears. And like the series of fossils they show nothing which is a complete failure ; indeed in one sense nothing which is a failure at all since everything has been found capable of being used at the time when it was formed. But some things were not on the line of progress. They did well enough at the time, but they did not show the way to something better, and so they were superseded when something better came, and they look like failures because their peculiarities were dropped. They are like those animals and plants which once flourished but whose kind is not seen now ; like the flying saurians, for instance, whose place is taken by the true birds. We may take the evolution of flying saurians as an attempt to find an animal to fill a vacant place in nature, and the evolution of birds as a better and more successful attempt, just as we may take the bow and arrow as an attempt to propel a missile against a distant enemy and the musket and bullet as a more successful attempt, and we may mark how in each case the more successful prevailed and the less successful disappeared.

We may also find in the changes and improvements made in the implements which were used for a long time an evolution exactly resembling the evolution of those families of plants and animals which have endured through long periods of time. No better picture of evolutionary progress could be imagined than is supplied by a full and well-arranged museum of fire-arms as used at various periods. There will be found a progressive series of improvements bringing one variety of the weapon up to a condition of great efficiency, when some slight change in construction appears and gives rise to another variety which runs through its course of evolution. Thus we have a series of guns with flint locks giving way to another series using percussion caps, while these are seen in the end to be subdivisions of the muzzle-loading kind, and to be followed in due course by a series of breech-loaders. I have been myself much struck by finding intermediate forms in a museum of arms which fitted in between those which are now familiar in the same way as many fossil organisms take an intermediate place between present species. Thus I have seen a weapon having a larger barrel than would be given to a musket, yet hardly large enough for a cannon, fixed on a swivel like some cannons, yet having the stock of a musket. There is, in fact, hardly any form or phase of evolution which may not find a parallel in such a museum.

That the variation of plants and animals under domestication is closely parallel to the evolution which is found in nature is a proposition which has been generally accepted since Darwin laid so great stress on it in his *Origin of Species* ; and, indeed, the more closely it is considered the more are we impressed by the resemblance between a new variety in nature and a new variety under domestication. We see here how a continual progress leads through a series of very small changes to what are in the end very considerable differences. And although we find that the variations of domestic plants and animals have limits beyond which it seems impossible to force them, we feel inclined to think it not altogether incredible that if longer time were given and continual progress were still desired our artificial varieties might at last become equivalent to natural species. Horses are bred for strength, and now if they have not attained a maximum of strength certainly their progress is so slow as to be imperceptible. Yet perhaps if it were possible to keep up the process of breeding and selection for ages we might have them at last as strong as elephants. There is no noticeable increase in the speed of horses now, yet possibly with great care and long patience some considerable increase might be brought about. If by these or other considerations we can get over the limit which seems to be set to our power over natural organisms the parallel between the result of human action and the result of natural evolution will be very close.

In all these instances of evolution we have the working out of purpose, we see design, foresight and everything that marks the presence of conscious intelligence. We learn, therefore, that intelligence, purpose and will by their usual way of working bring about such series of changes as we are accustomed to call evolutionary. If, then, the appearance of evolution in nature is held to make it unnecessary to suppose that mind, consciousness, or design is present, this cannot be due to the presence of evolution, but must be ascribed to the presence of some special form of evolution, or of evolution worked out in some particular way. It must be the special kind or manner of evolution which makes it possible to exclude the action of mind or purpose. And this is what is alleged to be the case.

CHAPTER V

THE QUESTION ABOUT EVOLUTION

THE question about Evolution has now taken its final form. We have set aside the mere fact of evolution as having no influence on the argument. We feel that whether an adaptation of means to end, of instrument to work, of organ to function, is made all at once by one effort or brought about in the course of ages by millions of efforts, all tending in the same direction, mind, purpose and design are equally necessary to account for it. We see undoubted instances of true evolutionary series produced as the result of design and purpose. It only remains for us to ask whether any kind or manner of evolution can be found or imagined for which the action of intelligence is unnecessary. It is not, of course, our business to enquire whether such a kind of evolution is actually now in operation. We are only concerned with its bearing on our argument.

Three doctrines of evolution have been put forward which have been, at least by some persons, supposed to account for the facts without having recourse to the idea of design. The first that we shall consider is the doctrine that evolution is due to an indwelling force or tendency in the organism. No proof can be given of the existence of such a force or tendency except the fact that evolution has taken place, combined with the belief that this hypothesis is sufficient to account for it.

To suppose the existence of a force or tendency is a provokingly vague and unsatisfactory way of accounting for anything. It amounts in general to little more than saying that what we find is produced by something that is able to produce it, which we may admit to be true without finding it very instructive, so that in this case we have to focus our attention on the fact that the force is supposed to be indwelling and to extract what we can from that.

With this clue to guide us, we are able to see that what is meant is that the evolution of the species is like the evolution of the individual. As the individual grows, or is evolved out of a seed or germ which contains in some way or other the power of producing such an individual, so may the race, species, family or order be supposed to be produced by some first or original seed or germ in which was contained the power of producing the whole evolutionary series with all the forms which it has exhibited during its past or may exhibit during its future existence.

We cannot doubt that the seed does in some wonderful way contain the plan of the tree. We see that it contains it because the tree grows out of the seed. We might then suppose that the original seed contained the plan of the series of plants which have been produced in regular order from the earliest times to the present day, and thus account for the evolution which we see in Nature. But when we come to think of it we see that this supposition does not commend itself to us in any way as making things more intelligible and that it does not at all dispense with the necessity for believing that Natural order is due to conscious intelligence. For we cannot think of the plan as included in the seed except we think of it in either of two ways. It may exist as a thought in a mind or as an arrangement or organisation of parts, like the arrangement of wheels and other parts in a watch. Now if it exists as a thought in a mind, then the order and arrangement displayed in the evolutionary series is due to design and purpose; but if it exists as an arrangement of parts, then to account for that arrangement or order we must attribute it to some conscious intelligence by whom it was designed.

The seed from which a great tree is produced may be a very small organisation of material parts, but it must be almost inconceivably complex. If we take it as it is we cannot suppose that such an arrangement could have come into existence without the presence and action of some mind or intelligence. Now how are we helped by being told to trace all back to a first seed from which the whole race of plants has been evolved? This first seed must have been immensely more complex, much more highly organised than the seed before us. It must have contained not only as much as this seed contains, that is the plan of the tree which is now to grow, but also the plans of all the trees or plants which have preceded it in the course of evolution, including those species or varieties which are not now represented by any living descendants. The mind absolutely reels and staggers under the weight of this thought. That such a complex organism should ever have existed is a belief which can only be entertained on compulsion. And when we have entertained it, are we not all the more forcibly compelled to think that such an organism was brought into existence by an intelligent agent, to whose design its complexity is due?

This view of evolution is the less attractive, because it puts the more complicated and more highly organised elements before the simpler, for undoubtedly nothing that follows has so much organisation as the original germ from which everything springs and which contains not only the plans of all that are to follow, but also something that determines the order in which they are to come to light. As the evolution works out, part of this design is used up and drops out, so that the farther down we go in the course of evolution the simpler we find the organisation of parts in the germ. Thus we avoid the necessity for the intervention of mind at the last stage only by assuming an increased necessity (if so urgent a necessity could be increased) for the existence of mind at the beginning.

The course of evolution which this theory gives us is also unsatisfactory, for it consists in the gradual passing over of the design from the germ to the plant, so that while the part which shows the design, that is the plant, is becoming more and more complicated, the part which conceals it, that is the germ, is in the same degree losing the complicated organisation with which the series began. We want to think of evolution as a progress, an advance, a series in which there is simplicity at the beginning and complexity at the end, but here everything goes the other way, while yet the series looks as though it were acquiring greater complexity as it went on. And it is hard to see why we should suppose a germ to contain a design which was destined to lie dormant for so many ages, or why a series of plants should exhibit an appearance of producing varieties, as it were, on trial, some of which seem to succeed and some to fail, although there is no trial, no success or failure, but only the unrolling of the plan which the organism contained from the beginning. We conclude, then, that we have found nothing, as yet, in the way of evolutionary theory to qualify the strong belief which we feel compelled to entertain, that every instance of order testifies to the action of conscious intelligence.

The next theory of evolution to be considered is that known from the name of its author as the Lamarckian. It is avowedly a theory to account only for the evolution of animals and is not applicable to the case of plants. This is certainly a drawback, as plants and animals show similar series of evolutionary forms coming into view together, and if we account for the evolution of animals after the Lamarckian fashion we shall have to find some other way of accounting for the evolution of plants. However, we must not say beforehand that there may not be some great difference between the two series, notwithstanding their close resemblance, and in any case we must take the theory as it stands and ask whether it enables us to think of certain cases of order and regular organisation as not proceeding from thought or proving the existence of mind. If it should do this it would supply us with a very trenchant criticism of our common-sense views.

This theory is often expressed in four propositions :—

" 1. Life, by its proper forces, tends continually to increase the volume of every body possessing it and to enlarge its parts up to a limit which it brings about.

" 2. The production of a new organ in an animal body results from the supervention of a new want continuing to make itself felt and a new movement to which this want gives birth and encourages.

" 3. The development of organs and their force of action are constantly in ratio to the employment of these organs.

" 4. All which has been acquired, laid down or changed in the organisation of individuals in the course of their life is conserved by generation and transmitted to the new individuals which proceed from those who have undergone these changes."

The last of these propositions takes a side on the question of the transmissibility of acquired characteristics. It may, however, be passed over here as we are less interested in asking whether the theory is true than whether it is a possible way of thinking of order without mind.

The first proposition assumes the existence and orderly character of life, but does not tend in any way to account for it. We are trying to examine the necessity which is laid upon us of supposing that order, wherever we see it, is due to the action of intelligence. We want, wherever we can, to go back to the beginning and to get at the foundation of things, and here we find our way stopped. Life is to be assumed, not examined. What is to us a most striking instance of order and one which, above all others, proclaims itself to be due to intelligence is removed from the argument. Its character is stated and then we go on to consider what happens when it has been established. Well, be it so. The only result is that what we are considering is not the origination or beginning of the order and organisation of animal bodies, but only the additional order, the increasing complexity which they show in the course of an evolutionary series.

The third proposition is a gross exaggeration of a fact. A limb or organ not used has a tendency to waste away and one that is much used to become strong and vigorous, but we have no reason to suppose that this increase in strength and vigour can go on without limit, or that it is in any proportion to the amount of use and exercise that brings it about. On the contrary, there is always a limit beyond which it is if not impossible yet certainly extremely difficult to cause any organ in an animal body to increase in strength and vigour, and, as this limit is approached, such efforts as may be made to that end produce continually less and less result. However, without dwelling too long on the question of fact, we may concede that it is at least thinkable that an increase which comes, as we see, by exercise may go on and be handed down from generation to generation until it shall exceed anything that comes under our observation.

And this brings us to the second proposition, which is really the central thought of this theory. It tells us that the production of a new organ results from the supervention of a new want. Now what kind of process does this imply? When we consider it well we see that it is a process which cannot go on without consciousness, foresight and purpose. The new want from which the process begins is a felt want, that is to say, it is felt as a want. It is not merely felt as uneasiness and discomfort, but as a definite want which is a spur to action. The examples given by way of illustration make this clear. The giraffe is supposed to have gained its long neck by reaching up towards the leaves above him, the snail to have acquired its projecting feelers by reaching on to the things before. Here we have effort produced by a desire to get at something out of reach, and this is nothing less than a definite consciousness of a want. This is something more than instinct. We find in instinct a definite action produced by a definite stimulus. The stimulus is felt at certain times, the corresponding action follows, and thus the life of the organism is carried on. But instinct only satisfies old and familiar wants, it contains no provision for anything new. If anything new occurs instinct can only produce the performance of some customary action which may be wholly inappropriate. Besides this, it can only give vague and aimless movements. The whale's instinct leads it to dive when attacked. As against its ordinary enemies this is a good defence, for it goes down to a depth at which there is a pressure which it can bear but which they cannot. But, as against the whaler, this defence fails and yet instinct can produce nothing better. When we talk, then, of a new want producing a new movement, the continuance of which results in the production of a new organ, we are attributing to the animal, or if not to the animal to some intelligence concerned in bringing about its evolution, a degree and kind of reason far beyond the bounds of instinct. In fact, what is required is a very high quality of inventive genius. There must be in existence a knowledge of the sort of new organ which is wanted and of the kind of motion which will bring it into existence, and this is what very few human beings could find out for themselves. Let us suppose that there exists a light and active kind of animal which finds it hard to live because a new enemy has come into the country which it inhabits. Here is a new want and a very pressing one. It wants a new way of escape. Now let us say that its true way of escape is to develop wings, but yet there has never up to this been a flying animal in the world. Must not some inventive genius of the very first order exist who thinks of wings and knows how they may be developed? I certainly cannot feel that my reasoning power would suggest wings and I have not the least inkling of the kind of motion that would tend to bring them into existence.

And if we take the examples usually given—the giraffe that stretches its neck by reaching up to high trees and the snail that acquires feelers by reaching forward with great eagerness—we find that here intelligent guidance is required. For why should this reaching and endeavouring produce the right thing? Why should not the giraffe grow horns or tentacles and the snail a long neck, or why should the determination of blood, which Lamarck supposes to be the result of the striving, as easily produce a mere induration or a sore? The fact is that all through this theory purpose and intelligence are taken for granted, but this escapes notice because the process is described in a vague and general way. When we pull it to pieces and demand thoughts, not mere vague words, we see that the supposed process of evolution cannot be stated intelligibly without presupposing a conscious intelligence exercising purpose and design as the author and director of it all.

We come, then, to the theory of evolution which has had the greatest effect on the course of thought in modern times, namely, that which is associated with the names of Darwin and Wallace—the theory of Natural Selection. It has been better thought out than any other theory of evolution and will repay a very careful examination. The points to be noted in this theory are these: First, the existence of organised beings as plants and animals producing their own kind from generation to generation is taken for granted. The object of the theory is not to account for the origin of life or the nature of life, but only for the evolution of life. Then it is asserted that the offspring of plants and animals have a tendency to vary slightly from the parent form. As plants and animals tend to increase amazingly in numbers there is a pressure on the means of existence and life is a competition for all. Therefore any variation which gives its possessor the slightest advantage over others may enable him to survive when they perish. This is what is meant by Natural Selection and the Survival of the Fittest. Lastly, the variations thus selected and preserved are transmitted to posterity, and by their slow accumulation through vast periods of time produce all the differences which we see in the animal or vegetable kingdom.

We have in this theory three points of great importance—Chance Variation, Survival of the Fittest, and Heredity—but, as we have already pointed out, all three presuppose the existence of the plant or animal in which the variations are to appear. We have then to begin by taking life for granted, and though life itself might give us the strongest evidence for the action of intelligence, we are to pass that over and consider only variations and developments. The same point has been noted with regard to the Lamarckian theory, and as in that case so now, the proper course is to pass on, taking the presuppositions of the theory for granted, and to ask what it has to say for itself.

We begin, then, with the existence of animals and vegetables having the wonderful power of transmitting to descendants an organisation like their own. But the plants or animals which are descended from a common ancestor are not all precisely the same. Amongst those which are swift there are some which excel in swiftness, amongst those which are strong there are some which excel in strength. Every quality which is inherited may be possessed in a greater or less degree. These are the variations which the supporters of the theory point out, and no doubt such variations occur.

That these variations may accumulate is shown by the results of the action of man upon cultivated plants and domesticated animals. Whenever one special quality in plant or animal is greatly valued so that the individuals which possess it are preserved in preference to others, that quality comes to be possessed in a much higher degree by the descendants of the individual in which it was first noticed. The limits of human opportunities of action and observation perhaps hardly allow us to say how far such changes may go, but undoubtedly they may go very far and result in very striking differences in the varieties of plants and animals so treated.

Now it is easy to find or to imagine the existence of conditions of life under which the degree in which some quality was possessed by the individual plant or animal would determine whether it would survive or perish. There is always a competition for everything that makes existence possible. Plants and animals multiply so rapidly under favourable circumstances that it is only the difficulty caused by the existence of other plants and animals which prevents the indefinite increase of any one species. As it is, the greater part of seeds fail to grow, the greater part of young animals fail to attain maturity. It is evident, then, that any plant or animal which is even a little better equipped for the battle of life than its neighbours will have a much greater chance than they of living and multiplying, and thus the circumstances in which the plant or animal has to live will form a sort of selecting medium, killing off the weaker and less efficient, and preserving those which are stronger and better suited to their surroundings. Whatever effect it has on our argument we must admit the idea of Natural Selection. If it does not bring about an improvement it certainly prevents a falling off in efficiency, and the result must be the survival of the fittest, that is to say, of those plants or animals which are best fitted for the particular place where they are obliged to live.

Having accepted the ideas of heredity, variation, natural selection, and survival of the fittest, have we anything more to discuss ? Does not the question whether these factors are sufficient to bring about the evolution which has occurred in nature depend altogether upon the degree in which animal and vegetable organisms can vary, and the certainty with which natural selection acts, and are not these points which lie entirely outside our limits? One of these points is certainly not without our limits. The degree in which animal and vegetable organisms do actually vary we must leave undetermined, but the limits of possible chance variation are of the utmost interest to us. Or, perhaps, it would be better to say that we are interested in determining what kind of variations may be held to come by chance. We have to ask whether it is possible to think that such variations may occur by chance, as being selected and accumulated, will be sufficient to account for the progressive advance in organisation which the evolutionary series exhibits. Our view has been narrowed down to the one question of chance variation, and to this we must devote the next chapter.

CHAPTER VI

WHAT CHANCE VARIATION MAY DO

We have compared the animal and vegetable organisms found in Nature with the machines which are devised by human intelligence, and noted the resemblances between them. We have now to dwell upon a character in which they differ. They are alike as being an orderly arrangement of parts, so put together as to work out an end to which they are evidently adapted by intelligent foresight, or at least we have argued that it is inconceivable that the parts should be so formed, adapted and assembled as to work out that end unless it were foreseen and provided for in their formation and arrangement. But now we notice that our machines and natural organisms are unlike in one respect, for natural organisms have a flexibility and adaptability which our machines do not possess.

Our machines are always rigid. They consist of moving parts held together by a framework, and if the framework is bent or any of the parts injured the machine ceases to work. If one of the wheels is removed from a watch it tells the time no longer. If one rod in a steam-engine is bent the machine stops, or only moves to break itself up. We can make no machine which will work if it is much knocked about and broken. But the machinery of the animal or plant will often stand a great deal of hard usage. In strange places with surroundings for which it was never intended it will still work on. It will endure a great deal of mutilation without stopping and will show a kind of pliability and adaptability that we can never communicate to a machine.

Most plants and some animals have even a power of supplying lost parts, so that a portion of the plant or animal will become a perfect individual again if the circumstances are not unfavourable. Everybody has noticed how a tree may be grown from a slip and how a small part of a potato will grow into a complete plant, and everybody has heard that many worms if cut in two will grow into two worms, and that many other animals which have not this power can go so far as to reproduce a lost limb. All this only shows us that the natural organism is a much more wonderful and complicated machine than any of our clocks and watches or other contrivances, and is a machine which could only have been devised by a much higher intelligence than ours. We have already used this characteristic of natural organisms to enforce our argument and to carry it farther. If it is inconceivable that a watch or a clock should come into existence without the exercise of intelligence and foresight it is much more inconceivable (if such an increase of inconceivability is possible) that the more wonderful and complicated plant or animal should come into existence without intelligence and design.

We have now, however, to notice that this quality in natural organisms enables them to respond to chances that may happen to them, and that thus they come to exhibit chance variations. All organisms and all machines are subject to chances. By chances we mean events which are not guided or controlled by intelligence. If I load a cart with stones to be conveyed to a certain place the whole event is arranged and designed by me, but if on its way the cart comes to a rough place in the road, of which I did not know and for which no allowance was made in loading it, and if in consequence some stones fall out, we call that chance. There is an absence of thought or design in depositing those stones at that spot, it was in no way meant or intended. Now machines cannot respond to chance. If a grain of sand falls into my watch it stops it, if a small stone is found on the railway line it will be crushed or thrust aside, if a large stone is there it will throw the engine off the rails. The engine does what it is made to do as its regular work, but it cannot do more. But see how a natural organism can adjust itself to chances. A feeble shrub by the side of the railway line is crushed under the weight of a stone large enough to throw the engine off the line, but it is not killed, it manages to grow on and soon covers and hides the stone with newly developed foliage. And plants and animals placed in strange surroundings manage still to exist, although with some change of form or colour. There are few common wild plants which if they are made to grow in a garden and carefully cultivated will not show considerable variation in form or colour, or both, and some will still grow and thrive under conditions surprisingly different from those in which they are found in nature, responding to the changed conditions by some change in appearance or habit.

This capacity of enduring variations in the conditions of life and of responding to them by some change in themselves is constantly exercised. For with all plants and all animals the conditions of life are for ever changing. And hence it happens that no two plants and no two animals are ever quite the same, but each has some individual peculiarity which belongs to itself alone. These individual peculiarities are chance variations and are produced by the chances which happen to plants and animals in the course of Nature.

Now we have come to a point where some kind of definition is necessary, for many will be ready to point out that the changes of season and weather and other external influences which bring about these variations in plants and animals, are not properly called chances, seeing they are the result of natural forces which cannot act otherwise than they do, and so they must in the strictest sense be called necessary. This is very true, but to the animals and plants they are chances, because their occurrence is in no way co-ordinated with anything in their life. Let us say that near the coast of a certain land there lives a species of butterfly of which many individuals are constantly blown out to sea and drowned. But one day there comes a tempest of unusual duration and fury and catches up a small company of these butterflies. It blows them much higher and farther than any such butterflies ever went before and finally deposits them on a little island far out to sea, where they are able to live, but under such altered conditions as will produce some change in the butterflies or in their descendants. Now the causes which brought about the tempest or arranged the state of things which existed on the little island had no connection with the butterflies and had no regard to their constitution, or character, or habits of life. The whole occurrence is what is strictly and accurately called chance. If the butterflies found enemies on the island, they were not put there to be their enemies, and if, on the other hand, they found it a peaceful haven of rest, where no enemy disturbed them, it was not so provided for their sakes. Whatever necessity may have governed, the coming of the tempest or the existence of the island, there was no co-ordination between either and the existence and character of the butterflies. This example may show what is meant by chance, and that chance is not opposed to necessity but to intelligence and design. If it could be supposed that the tempest was produced for the purpose of carrying the butterflies to the island the case would be very different, but as nobody would suggest such a thing its effect upon the butterflies must be ascribed to chance.

There are many other things always acting on animal and vegetable organisms which must also be called chances. Some seasons are favourable and some are unfavourable to particular species, but we do not suppose that the weather is made for each plant or animal that is influenced by it. A wet summer does not show a design that snails may multiply, nor a warm summer a purpose of increasing the number of wasps. It is not in such coincidences as these that we see the reign of order and the evidences of design. These are chances, and all plants and animals are subject to chances, and in response to them show chance variations.

But chance variations are strictly limited by the existing constitution of the organism. It can respond to chances, but only to a limited extent. If the pressure put on it is too great the organism does not respond or modify. It perishes. An animal can live in a somewhat colder climate than its native place, but it must not be too cold, a plant may grow in a drier soil, but it must not be too dry. And as its constitution always limits the amount of change which the organism can bear, so it limits the kind of response which it is able to make. Whales may vary, but they will not produce feathers, dogs may vary, but they will not grow beaks. The effect of these chances is only to put some pressure on the machine so as to alter its way of going, but it will still continue to be the same sort of machine, it will have the same works and will produce on the whole the same result. The element of chance which brings about the variation is limited by the order which exists in the organism. As it does not destroy that order it can only act on it, and what happens is thus strictly controlled by the pre-existing order. Chance cannot put new or additional order into anything, it can only act upon and with the order and arrangement already there. Chance may alter the rate of going of my watch, but no chance can add to it a repeater action.

The variations found in plants and in animals are generally such as would be produced by this limited action of chance controlled by an existing order. If we take any series of events subject to chance but limited by order we shall find that if they can be measured or counted they will arrange themselves in a certain way. As an example of such a series we may consider the marks made on a target by a number of shots fired with the intention of hitting the bull's-eye. The element of order here is the fact that all the shots are aimed at the bull's-eye. The chances are little nervous and muscular tremors, pulsations in the arteries and other trifling disturbances which the marksman is not able to control. The result is that the marks become grouped around the bull's-eye in such a fashion that if we measure the distance of each mark from the centre and tabulate the result we shall find that it shows a certain kind of regularity. There is a certain distance from the mark at which the shot is most likely to be placed which corresponds to the most usual combination of favourable and unfavourable conditions, while extremely good shots which imply a very favourable combination and extremely bad shots which come when the combination is very unfavourable are few in number. The longer the trial continues the more clearly is the series defined, and the more probable it becomes that a shot-mark will be found at any given distance from the centre. Now the ordinary variations of any character in plant or animal, if of a kind which admit of being measured and recorded, will exhibit a regular series of gradations which may usually be shown as a frequency curve of a symmetrical form, the slighter variations being greatly preponderant in number, while the greater and more striking differences, which breeders and gardeners call "sports," occur but seldom. In so far as these variations are irregular the irregularity is due to the chance character of their causes. They come from the fluctuations of wind and weather, the irregularities in the supply of nutriment and the various other chances of life to which all living beings are subject, and these are in no way co-ordinated with the strength or needs of the organisms on which they act, but arise quite independently of them. But in so far as the variations show regularity or symmetry in their character, amount or frequency, this is because they are limited by the nature and constitution of the organism in which they appear, which can only vary in certain ways and will only respond to external influences within certain limits and also by the regularity and order of Nature, which brings round the influences of times and seasons in a certain regular cycle. In fact, the whole character of the variations which commonly occur in plants and animals corresponds to that of a series of chances which can only appear within certain limits. Such chances usually form regular series of a definite character and give results which admit of calculation.

But such chances can only produce changes within the plan of the organisation as it already exists. They cannot add anything to it. The order which is there already may be varied, but it cannot be increased. This is a point which must be hereafter considered. To take it up now would be to interrupt our present subject, which is, What chance variation may do. We shall, however, be able all the better to concentrate our thoughts on this question when we have noted that we have still to ask what it is that chance variation cannot do.

We have already seen that the Darwinian theory depends on Chance Variation, the Struggle for Existence and the Survival of the Fittest. We assume that these are all realities, that there is a contest between various forms of life of which only some can exist and the rest must perish and that chance variation sends at least some candidates for continued existence into the battle; what we have to consider is whether it is possible to allow that chance variation produces them all; so that we begin by asking how much we can suppose it able to do.

What chance can do is evidently to knock about and alter the wheels of the machine, so far as this can be done without stopping it. Inequality of nourishment may make one part of an organism more vigorous than another, pressure or irritation may increase or diminish growth. We may admit that in this way great changes are possible within the plan of the organism. For the organisms we find in Nature are pliant and will carry on their work with some degree of adaptation to circumstances. They do not stop, although the position of the wheels is somewhat altered. There are many positions which are possible without altering the plan of the machine. The design admits of being worked out in more ways than one. And if a chance blow knocks the machine into one or other of these possible positions it will still go. This is all that chance can do. It cannot add anything to the plan. It cannot produce order. It is limited by the degree of order that it finds already existing. If the machine is pressed beyond what its design already contains it will be destroyed. Chance can only add confusion if it adds at all.

Now this is exactly what human selection has to deal with in the case of domestic plants and animals. Darwin took human selection as his great example and built upon the analogies between it and natural selection. But human selection can only watch and wait for chance variations. It cannot directly act upon the constitution of a plant or animal so as to bring about a desirable change. It is, in fact, selection and nothing more. And accordingly we find that it never changes the plan of the organism but always works within the limits which we have ascribed to chance variation. There are many varieties of pigeon, but none of them shows the slightest sign of becoming anything else than a pigeon, there are many and different roses but every one of them is most decidedly a rose. The varieties which have been produced by selection in the course of many generations are really sufficiently great to be called species if they had the stability of species, but they are all strictly confined within the plan of the organism. Nothing has ever been added to the powers and capacities already inherent in it. So much as man can do, we may admit that Natural Selection may do, working always on chance variations, and it may do its work more perfectly than man does his. It may produce new species within the same plan or design, but it cannot add anything new to the design. Chance cannot produce any additional order, it can only bring out possible variations in that which already exists.

CHAPTER VII

WHAT CHANCE VARIATION CANNOT DO

I TAKE it that nobody who thoroughly appreciates the force of the evidence which is now available can really doubt that the plants and animals now living on the earth came to be what they are by a course of evolution. If we could obtain specimens of every sort of thing which has lived here since life began we cannot doubt that they would show us an uninterrupted series of forms, connecting the simplest organisms at the beginning with the highest and most complex at the end. They would therefore testify to a continual progress, a steady rise in the scale of being, a constant coming in of new designs, fresh kinds of organisms, more complicated living machines. It is this upward progress, this coming in of a new design, this additional complexity that cannot be ascribed to chance. For chance can never produce order or make a design, it always tends to confusion, and can only at the outside bring about some variation in the order which already exists. And even this possibility of bringing about a variation in existing order is only found where the machinery is tough and resilient, and, therefore, able to suffer chances without being brought to confusion as natural organisms are, but as the machines that we make are not. We can therefore believe that Natural Selection working on chance variations may produce new species when nothing is seen but some change in the arrangements already made, but when any novelty is introduced, any new plan exhibited, there mind has been at work, there we have plain proof of the exercise of intelligence and design. And, therefore, we say that the world is full of the evidences of the existence of God and that all Nature combines to declare His glory.

It is no more possible to believe that chance can add to a design than it is to believe that chance could produce it at the first. If I cannot believe that it was by chance that a number of stones on the surface of a field fell into the order which spells my name, it is equally impossible for me to believe that now that my name is there other stones will be dropped by chance which will spell my address. The existence of a certain amount of order makes no change in the effect of chance, except in so far as chance is limited by existing order. Beyond the limits of existing order and design chance is pure and unlimited. It can bring nothing new. It cannot take the place of thought.

Nobody could or would believe that any chance assemblage of wheels, bars, screws and springs would produce a watch. Could anyone believe that such a chance assemblage might add chimes to a clock or watch already existing? Nobody could and nobody would. Why then do some imagine that chance variations may account for the advance of an animal organism from a lower to a higher stage in the scale of being? Because they quite overlook the distinction between changes that add nothing to the design and changes that bring in something new, between changes that only demand the maintenance of the old co-ordinations and changes that bring in new and additional co-ordinations. But when the distinction is once grasped it will be felt that everything that tells of upward progress and also whatever shows a change to another plan, even though it should not be a higher one, is a distinct evidence of an intelligent designer. The power which living things possess of resisting the disintegrating and disorganising effects of chance is very wonderful, and is, indeed, one of those things in which we see the testimony of Nature to its Divine Author, but this does not amount to a power of making chance anything else than chance, or of putting it to do the work of intelligence and design. It would be as easy to believe that the Sphinx is merely a rock which has come to be of its present form as the chance result of long ages during which it was worn away by the continual friction of the desert sands that were blown against it, as to think that the organisation of one of the higher animals is the result of fragments of design, each the work of chance and all added together by Natural Selection.

We cannot now imagine that even the least addition to the complexity of any natural organisation is a small thing, involving only an addition of a few parts. We know something of the structure of matter and of the almost infinitesimal size and almost infinite number of its smallest parts. Even a single cell of the simplest character must be composed of many millions of distinct molecules, and all these must be arranged in strict order in accordance with the design of the cell and the part which it is to play in the animal or vegetable organism. And we know that to bring about any addition to the plan of the organism many millions of cells must be produced, all having a new plan which did not exist before. If we could suppose that such a thing might happen by chance it would be a small thing to expect that a sonnet might be composed by throwing down at random little cards on each of which a letter was printed. If we could imagine it reasonable to think that the new cells might thus arise by chance because the old cells were already there, it would be a reasonable and hopeful project to continue the series of Shakspear's or Wordsworth's sonnets by putting the letters of the existing sonnets on separate cards and jumbling them up into a chance arrangement.

To those who suppose that chance variations may account for everything, if by any means those which are most suitable can be selected and preserved, the case seems to present itself in this way, We can suppose some one alteration to occur by chance, then why not another, why not any other? One particle may by chance alight on the proper spot, why not also a second and a third? It is only a matter of chances, and if a sufficient number of trials be granted anything that is needed will certainly arise. The mistake here lies in thinking that the arrival of a second particle and a third at the right place are events of the same kind as the arrival of the first. For the reason that there seems to be nothing impossible in the arrival of the first particle at the right spot is that it is taken to be a solitary event, unconnected with any other. The particle must be somewhere, why not there as well as anywhere else? But the reason that the arrival of the second is of any importance is that it is not an unconnected event, but is linked on to what has gone before and forms a basis for what is to follow. In an orderly arrangement every event is co-ordinated with the past and the future, and this co-ordination is not fitful, it is not a thing that comes and goes; it is steadily maintained, and must be steadily maintained, during the building up of the whole structure. Now this co-ordination of the present with the past and the future is an act of thought; it manifests purpose and exhibits a plan. To ascribe it to chance is to suppose that co-ordination arises without any cause to produce it. And therefore when we see a particle arrive at the spot where it is wanted, if it is a solitary particle unconnected with any other, we may ascribe its arrival to chance, but, then, it means nothing and effects nothing. But if it is one of a series building up a regular structure, if it means something and effects something, then there must be a reason why the series is a series; it must be due to intelligence and design.

If a chisel is thrown at a block of marble it may happen to knock off such a chip as a sculptor would take by his first stroke; if a small piece of plaster is thrown at a broken plaster cast it may happen to fall just where it will fill up a hole. But it would not be reasonable to set a blindfolded man to throw chisels at a block of marble in the hope of producing a fine statue, or to employ him to throw small pieces of plaster at broken casts in the hope of effecting repairs. For the regular effect which is required is not produced by isolated blows or unrelated pieces of plaster, but by a series of efforts made into one by a constant regard for the purpose of the whole. The first stroke that the sculptor makes is made in subordination to the whole design. It is the continued consciousness of this design that gives regularity and order to his work. If you take away the consciousness of a design, as you do when you trust to chance, you take away the cause of the order, and, taking away the cause of the order, you cannot expect the order still to remain. We do not find events in Nature happening without sufficient cause. And, therefore, we cannot ascribe to chance variation any increase in the complexity of a design, any novelty in the plan of an organism, any rise to a higher place in the scale of being. All these, wherever they occur in Nature, are evidences of an intelligent designer.

CHAPTER VIII

CREATIVE EVOLUTION

It seems necessary to add a supplementary chapter to this argument in order to notice the theory which M. Bergson has put forth under the name of Creative Evolution. M. Bergson's theory must be treated separately rather than together with those of Lamarck, Darwin and others, because they are merely theories of evolution, but his is a philosophy and is therefore both more ambitious and conceived in another spirit. It may be asked, indeed, Why should a philosophy be here discussed at all, or how can it properly be discussed in the course of what professes to be merely a common-sense argument? We certainly cannot enter into its bearings as a philosophy, but we may very well consider what it has to say to our argument, for the common-sense argument stands on its own footing and is independent of philosophical systems.

In fact, the common-sense argument rests on the basis that there are certain primary or fundamental beliefs which are involved in all our life and action, and which cling to our minds in such a way that they can never be got rid of. To invoke such beliefs is to produce conviction, and that is what the argument aims at. But the business of philosophy is to take these beliefs and to value them or explain them, to find out, in fact, whatever can be found out about them. They are the most important part of the material with which the philosopher works. All that we are concerned with, then, is to make sure that we have one of these inevitable beliefs, we are not concerned with what the philosopher does with it.

We do not even mind if he chooses to deny it. To one who has not reflected on the matter it may seem strange that he should be able to deny it, but in reality it is not even difficult. For the philosopher makes a distinction between speculation and life, and in his study, as a matter of speculation and theory, he denies a belief on which he finds himself compelled to act the instant he ceases to speculate and theorise and turns to discharge any of the ordinary functions of life. With such denials we are not concerned. They are possible only because these fundamental beliefs are so fundamental that they do not exist in us as statements and propositions, but as habits of thought and reason, and statements expressed in words may float on the surface of the mind without ever coming into contact with the fundamental belief which exists rather as a mental habit and scarcely seems familiar when expressed in words. But every philosophy which demands the denial of a fundamental belief contains the cause of its own destruction. Some time or other, if not in the time of its founders, yet in the time of their followers, the fence which keeps the doctrines of the philosophy in one compartment and the fundamental belief with which they are inconsistent in another breaks down and the opposite principles come together. And then the philosophy loses its persuasiveness and its force, and fades away until it takes its place amongst old, forgotten things. Our libraries are full of the records of such systems. Once they were influential and now nobody heeds them. They have never been refuted. A great genius built each of them up, but no one ever took the trouble to destroy it, and yet there they are, like ruined and deserted cities whose inhabitants have forsaken them through some strange caprice. But they have perished through their own weakness. Their founders yielded to the temptation of making their way easy by setting aside some fundamental belief, and so they only left their successors an inheritance of confusion, inhabited for a while with restlessness and finally abandoned in disgust.

M. Bergson consistently denies the fundamental belief on which our argument is built, but he never faces it fairly or makes any attempt to thrash it out; he rather tries to evade it and to produce substitutes for it, building up fences as he goes on by which he tries to keep it away from the centre of his philosophy. It may be of interest to see how he does this.

Life, he says, in the course of evolution acts as an impulse or force pushing from behind and urging on every organism towards a fuller and more perfect condition. In the progress of evolution it has deposited the human intellect as a guide to action when dealing with inanimate things, this being what was most necessary for the human race. Intellect, therefore, is able to deal with lifeless objects and thoroughly understands them, but fails to comprehend life and is unable to deal with it.

As the weight of this statement rests on the supposition that intellect was intended to meet the practical needs of human beings, it is absolutely impossible to understand why its scope should be so limited as to apply only to objects without life. Surely the farmer finds it as necessary to understand the crops he grows and the animals he rears as the soil or stones that he meets with in the ground; the fisherman must know the fish as well as he knows his nets and lines, and the hunter must know the ways of the beasts he pursues as well as the ground over which he pursues them. And to all, the knowledge of their fellows who belong to the same community is not the least necessary kind of knowledge. In fact, it is impossible to understand how any other knowledge could be of use and could enable a man to live if a knowledge of life were omitted. It is not even possible to say that man has used lifeless things only as his implements and, therefore, has needed a special knowledge of their nature, for he has made his greatest advances by subduing the beasts themselves and using them as his implements to carry on his work. And surely it is impossible to say that the intellect which discovered how to domesticate and use so many animals is an intellect which cannot understand life.

The reader will probably take but a languid interest in such arguments as these. He will feel that his mind never hesitates to deal with life as well as matter, and that in any special case his judgment is irresistibly controlled by the fundamental belief which it has been the object of this argument to bring into full and clear consciousness. And, therefore, as he realises that when the case is fully and clearly presented to his mind his decision is never for a moment in doubt, he will feel that speculations as to the origin of these beliefs are not very important and attempts to limit their influence are utterly futile and vain. Nothing can be more true than this from the point of view of common sense, which aims only at the attainment of practical certainty with regard to the things and events which come within the bounds of experience and is quite satisfied with a conclusive decision as to their nature and quality, and, therefore, leaving points of philosophy to philosophers, we shall take up another point in M. Bergson's theory of evolution.

This point is that evolution is produced by the impulse of life which, first manifesting itself in simple organisations, presses on to conditions of greater complexity and higher degrees of perfection. We pause here and ask, What is this life of which he speaks? He expressly says that it is not an abstraction, but we are compelled to ask, What else can it be? What can we find within the limits of our experience which deserves the name of life, and is not an abstraction? We know living plants and living animals, but do we know or can we find anything that could be termed life which is not bound up with the existence of some particular plant or animal? We do not find whiteness anywhere but only white things, we cannot discover hardness but only hard things, we know of no life but only living things. We therefore call hardness, whiteness and life abstractions, that is to say, particular qualities or attributes of things which we find it convenient to consider apart from the things to which they belong, but which are never discovered actually existing apart from them. But if life is anything more than this M. Bergson might have told us what it is. Does he regard it as a substance put into the earliest organisms, as water might be put into bottles, or is it to be taken to be a mysterious essence or general quality such as mediæval logicians dreamt of by partaking in which particular things acquired their special nature? In this sense a man was supposed to be man because he was a partaker in humanity, and living things would be living because they had in them the essence of life. It is hard, indeed, without going back to some ancient form of Metaphysics to find any concept which will fit M. Bergson's description of life.

What is of the greatest importance from our point of view is that it is a confused description. To life taken in this general and abstract way he ascribes, without any difference or distinction, all the powers manifested by any form of living thing under any circumstances, and other powers such as no living thing has manifested or, indeed, ever can manifest because they are plainly absurd.

To us there is a clear difference between life that is mere life and life that is conscious and intelligent, and we cannot ascribe to mere life the actions of which only intelligence and consciousness are capable. M. Bergson lumps all life together that he may ascribe to it always and everywhere all the qualities of which it is anywhere capable, and especially that he may attribute to a blind striving and an unconscious impulse that increase of order and complexity in organisation which we can only attribute to conscious purpose and design. Here, as so often before, our argument is reduced to an exposition. We have shown the foundation on which we build and we can do no more than show it. Because it is the real foundation we can discern nothing beneath it, because it is a fundamental belief we can add nothing to its cogency.

As M. Bergson rejects the only explanation which the human mind can accept as a real explanation of the existence of order in an elaborately constructed organ, it may not be amiss to enquire what he proposes to substitute for it. His most interesting statement is that the organ is only the act for which it is used. This, no doubt, sounds rather mystical, but it is literally what he says. Here are his words regarding the eye: "So the eye, with its marvellous complexity of structure, may be only the simple act of vision, divided *for us* into a mosaic of cells, whose order seems marvellous to us because we have conceived the whole as an assemblage."[1] This is, indeed, an abstruse and marvellous utterance. We do not know how to set about conceiving that an action can *be* an organ. It seems like asking us to say that a posture may be an acrobat or that a tune may be a piano. We notice that the eye exists both before and after the act of seeing, whereas if the eye *is* the act of seeing it should only be there during the time when the act of seeing is performed. The act of seeing is transitory, the eye is permanent. There is no act of seeing in the darkness, but the eye is there all the time. And if the eye is only the act of seeing, what of a pair of spectacles? Is that also only the act of seeing, divided *for us* into glasses, rim and legs because we have conceived it as an assemblage of parts. And if it is something more than the eye, why should it be anything more? But, perhaps, Nature was formerly more vigorous than now, and then an act of seeing was an eye, but in these times its powers are failing and it cannot even accomplish a pair of spectacles. M. Bergson, however, has an illustration by which he supposes that this conception is made clearer and that we may now examine.

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[1] *Creative Evolution* (English translation), p. 95.

" If I raise my hand from A to B, this movement appears to me under two aspects at once. Felt from within it is a simple indivisible act. Perceived from without, it is the course of a certain curve, A B. In this curve I can distinguish as many positions as I please, and the line itself might be defined as a certain mutual co-ordination of these positions. But the positions, infinite in number, and the order in which they are connected, have sprung automatically from the indivisible act by which my hand has gone from A to B. Mechanism here would consist in seeing only the positions. Finalism would take their order into account. But both mechanism and finalism would leave on one side the movement, which is reality itself. In one sense the movement is *more* than the positions and their order; for it is sufficient to make it in its indivisible simplicity to secure that the infinity of the successive positions as also their order be given at once—with something else which is neither order nor position, but which is essential, the mobility. But, in another sense, the movement is *less* than the series of positions and their connecting order; for to arrange points in a certain order it is necessary first to conceive the order and then to realise it with points, there must be the work of assemblage and there must be intelligence, whereas the simple movement of the hand contains nothing of either. It is not intelligent in the human sense of the word and it is not an assemblage, for it is not made up of elements. Just so with the relation of the eye to vision. There is in vision *more* than the component cells of the eye and their mutual co-ordination: in this sense neither mechanism nor finalism go far enough. But in another sense both mechanism and finalism go too far, for they attribute to Nature the most formidable of the labours of Hercules in holding that she has exalted to the simple act of vision an infinity of infinitely complex elements, whereas Nature has had no more trouble in making an eye than I have in lifting my hand. Nature's simple act has divided itself automatically into an infinity of elements which are then found to be co-ordinated to one idea, just as the movement of my hand has dropped an infinity of points which are then found to satisfy one equation."[1]

This is far from being a satisfactory or convincing illustration, although it may very well be the best that can be found. For the eye, which is supposed to be or to result from the act of vision, is an actual material organ, whereas the line which results from the motion of the hand is no construction or organisation at all, but only the path in space over which the hand has moved. Not being marked out in any way it is only an imaginary line, which is not preserved and cannot afterwards be perceived or recovered. The hand, in fact, has made nothing, but has only moved from one position to another and the path of this motion, of which no trace remains, is to be taken as equivalent to the eye, which can be examined and dissected long after the act of vision has ceased. But surely the eye sees in the same sense in which the hand moves, and if the act of vision is the eye, then the act of moving is the hand, and we must take it that the movement of the hand is *for us* the complicated assemblage of muscles, veins, nerves and so forth, which we call a hand, just as we have been asked to accept the same explanation of the eye.

The temptation to invert the comparison arises from the mathematical explanation which M. Bergson gives of the nature of the movement. But this mathematical explanation is quite beside the point. For the mathematical equation defines a curve by its relations to certain lines from which measurements can be taken. If you have these lines you can find any point on the curve, if you have the curve you can lay down the lines, but in a case like this, where you have neither, there is nothing to which any equation can be applied. The curve might, indeed, be marked on paper if the hand were provided with a pencil, but this would be constructing an object by the use of implements, something perhaps really more like the construction of the eye, but not such an action as could be made a prop for M. Bergson's argument.

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[1] *Creative Evolution*, p. 96.

Perhaps it may be said that any curve may be regarded as determined by its equation, even though no line has been drawn or position taken by which it could now be recovered, and, of course, this view is justifiable. But it is not justifiable to give us such an imaginary and now non-existent curve as analogous to such a thing as an existing and enduring eye. If I am to understand how an action can be an organ I want, as an assistance to my thought, an instance of some action which is something or does something which remains when the action is over.

But even though we overlook all these difficulties, the comparison does not help us at all. For a line is not a series of points and the hand cannot be regarded as shedding a shower of points as it moves along its path. It is by a mere convention that a line is regarded as a series of points. For certain purposes the series of points may do as well as the line, but for other purposes the two are by no means equivalent. The mathematician cannot really describe a curve by his equation, he can only undertake to find any point in it that may be desired. If he wanted to draw an ellipse or a parabola he would never try to make it by working out equations, and if he did set to work on the equations he would never attain to a real line but only to a row of points. The line exists because it has been described or marked out and before it was described it had no existence. The points are only possibilities until they are severally marked out and taken. Before any point is actually marked or defined it has no existence. And when they are brought into existence they are the work of intelligence. It is the intelligent action of the mathematician which creates the point when he solves the problem proposed to him.[1] We cannot gain much by comparing an eye which does exist with a series of points which may exist provided some intelligent agent is found to bring them into being.

There is one part, however, of M. Bergson's exposition which must be simply contradicted. He says of the movement of the hand: "It is not intelligent in the human sense." Now he supposes all through that the motion lies in a regular curve, but nothing is more certain than that a regular curve could never be described by an organ such as the hand unless it were under the direction of intelligence. A regular curve might be described by a mechanical instrument whose parts could only move in certain ways, but the existence of this instrument would be the result of intelligent action, but, for an instrument moved by muscles and controlled by nerves and not mechanically limited to a certain swing, a regular path must always be the result of design. This is, perhaps, the most important point that has been made, for it shows us how, under cover of an erroneously described comparison, M. Bergson evades the necessity of ascribing the existence of the eye to the action of intelligence.

But in whatever strange and mystical sense it may be said that the eye is only the action of seeing, it is evident that this does not apply to any existing eye. For every existing eye is fully formed before it has any opportunity of seeing. Nor if the doctrine of biologists is sound, that the history of the individual recapitulates the history of the race, can it be true of any former eye, since they, like their present representatives, must have been in their formation independent of light or seeing. Unless, therefore, the statement applies to some ideal and merely imaginary eye or, possibly, to some plan or design of an eye antecedent to the existence of any actual organ of sight, it can hardly have any application at all. But all these applications appear to be expressly repudiated. We have not therefore yet succeeded in finding any intelligible meaning for the remarkable proposition that the simple act of vision is the eye.

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[1] *Creative Evolution*, p. 61.

There is, indeed, in M. Bergson's first chapter another attempt at explaining this difficulty.[1] It is done by recasting the illustration of the moving hand. We are now to suppose that the hand is thrust into iron filings, which offer resistance and finally stop it. At the moment when it stops, the iron filings will be massed in such a way as to show the form of the hand and as much of the arm as has entered. The hand and arm are supposed to be invisible, and then lookers-on, if they are mechanists, will seek the reason of the form in the action of one grain of the filings on another, so determining the position of each by the action of neighbouring grains, while, if they are finalists, they will talk of a plan of the whole quite overlooking, of course, the true explanation that there has merely been one simple and indivisible movement, which is expressed negatively by the position of the grains. There is no synthesis of grains of iron filings, they merely canalise and limit the motion of the hand. This is very nearly the relation of vision to the visual apparatus.

But if in addition to those convenient bystanders who make remarks so easily refuted, we ventured to introduce as a third the common-sense person to whom this argument is addressed his reflections might, perhaps, take another course. He might say that the real reason why the particles of iron filings take that particular shape and no other is that the hand and arm act as a mould against which they fall and adapt themselves to it, just as wine or water adapt themselves to the shape of a vessel into which they are poured. We have here, then, merely an example of the mechanical adjustment of a substance to a mould. Now

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[1] *Creative Evolution*, p. 99.

M. Bergson has argued[1] that the eye does not present the appearance of being a mechanical adjustment. There is no form and no mould, life must create a form for itself. He is speaking there of the relation of the eye to the circumstances in which it is placed, but surely the appearance of being a passive adaptation is one appearance which the eye may have or may be without, but which it cannot have on page 99 and be without on page 61. But, indeed, the whole comparison only makes the confusion greater, for how can we imagine the simple act of vision to be a mould capable of shaping such an organ as the eye with its lens, its iris, its retina, its muscles and all its other innumerable parts? Or if we keep to the letter of the comparison and take the simple act of vision to be the act of thrusting the mould into the iron filings we have still to ask what is this mould and whence came it and what does it add to the simple act of vision? There is surely scarcely anything to which the eye has less resemblance than to a form moulded by one indivisible act.

All this is really rather out of the way of our argument, but it is very hard to follow a philosopher and yet to keep clear of philosophy. It is well, however, to point out the extraordinary shifts and contrivances that have to be used when an attempt is made to account for order without attributing it to conscious foresight and design. We could not ask for a better testimony to the value of our argument than the melancholy writhings and contortions which are the consequence of a departure from it. The lesson which we have learned has also a value which goes far beyond the benefit of discerning a point of weakness in M. Bergson's reasonings. For his is only one of a class of systems which treat reality in the same way and offer explanations of a similar character when they try to account for the things which we commonly experience. These systems generally take the idea as a sufficient explanation of all that happens or exists in accordance with it. They overlook the necessity for conscious beings to think the ideas and active beings to carry them out, and always regard the idea as carrying itself out and producing the results which are observed. Thus M. Bergson, gathering together the change and development of living things in the course of their evolution, forms an idea of life beginning with something very simple and gradually dividing into many forms of living things and evolving as it does a great variety of organs for sensation and action until it arrives at the highest and most complex organisms which exist. This idea consists of nothing more than the facts of the case as they are known to him considered as one regular course of events, one continuous process of evolution. But now he puts this idea at the beginning of things he calls it life and he imagines it to be endued with such innate power or force that it gives out all that it contains and forms the whole series of living organisms as it has existed and still exists on the earth. And he does not see that this life is only an idea or a word, the power, force, *élan* or impetus which he attributes to it, a mere baseless imagination, and his whole explanation nothing better than telling us that what has happened has happened.

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[1] *Creative Evolution*, p. 61.

We want to know how order has come to appear, how it has become more complex and elaborate, how material particles have been united and arranged so as to become useful organs, how other groups of particles have been arranged and added on to these so as to make better and more useful organs, and all we get is that this is the work of life and that life has forced itself into matter and arranged it through its original impetus, its formidable pressure, its irresistible advance. The real question, How can any order spring up or increase without conscious foresight and design ? is never faced and answered but always evaded and passed over. And in this, as has been said, M. Bergson only gives a sample of a whole class of philosophies.

Suppose that I am asked to account for the existence of so many houses, castles, churches, cathedrals, town halls and other buildings throughout Europe. I begin by laying it down that every such building was due to a purpose entertained by those who caused it to be constructed, and that that purpose was expressed in the architect's plan and carried out by the builders. I have thus provided in outline an account of the origin of the design and the addition to it of effective force to set up the building. But before I can go any farther the Philosopher sweeps it all away and will have none of it. He accounts for everything by the one idea of Gothic Architecture taking its rise in France spreading by an irresistible impulse into all the neighbouring countries and everywhere depositing in its course castles, churches, cathedrals, palaces and other buildings. With this idea of Gothic Architecture before us we need not resort to the hypothesis of Architects labouring at the construction of designs and masons laying stones in mortar, the *élan* of Gothic Architecture with the formidable pressure which results from it will sufficiently account for all.

Or if I observe in many different places of worship that prayers are offered up sometimes with the accompaniment of music and incense, sometimes without, sometimes with elaborate constructions and ornamental surroundings, sometimes with everything severely simple and bare, and if I am disposed to account for these differences by many reasons doctrinal, historical and social, I am stopped again. Nothing of the sort is necessary to the Philosopher. He sees merely the various acts of worship or rather the one indivisible act of worship forming its surroundings to suit it. As a hand and arm thrust into a heap of iron filings, more or less deeply, accounts for the form they take, so the act of worship entering into its surroundings forms them and is expressed by them. We need nothing more than this to account for everything that we observe.

By contemplating such a system as M. Bergson's we become more clearly conscious of the true character of our own argument. For what we are looking for is an explanation of the facts before us. Now what M. Bergson or any philosopher like him gives us is merely a summary or statement of the facts themselves, which he calls an idea and endows with an imaginary power of carrying itself out. The dissatisfaction which this gives us makes it plain that what we are asking is whether these facts are ultimate facts, beyond which we cannot go, or whether there is anything known to us by which they may have been brought about. And when the facts are or involve the origin or increase of order we see that they are not ultimate facts, but that other facts may be conceived to have gone before them from which they have been derived, and these preceding facts are always conscious foresight and design. The presence of foresight and design satisfies the mind and accounts for the order observed, but words like life, force, *élan*, impulse, give no account or explanation of anything, and, if they are to be understood as denying the existence of foresight and design, they make it incredible that orderly arrangement and co-ordination of parts should come after them.

NOTE ON MENDELISM AND MUTATIONISM

It is impossible to pass on from this point without making some references to the discoveries of Mendel and de Vries. They have excited very great interest amongst naturalists, because they promise us a clearer insight into the relation between a parent organism and those which are descended from it, and a better knowledge of the variations and changes which may be expected to arise in the course of descent under ordinary and under special circumstances. The knowledge which has actually come to us through Mendel's discoveries has also proved already to be of great practical importance, enabling breeders of animals and cultivators of plants to do deliberately and with certainty much that had only been attempted before in a wild and haphazard way. Results may now be attained by deliberate and reasonable action that formerly only came by happy chance or at the bidding of some instinctive and uncommunicable skill.

This would, however, hardly warrant the introduction of the subject here, even in the form of a note; and these discoveries have no direct bearing on our main argument, which is the nature of the upward progress that has occurred in evolution, the change from lower to higher, from simpler to more complex organisation. Neither Mendel's nor de Vries' discoveries show us any progress of this kind. But they show us many possibilities of change on the same level. They lead us to mark more clearly and understand more accurately the distinction between changes that keep to the same level and changes that denote an advance. And as everything that accentuates this necessary distinction is of value they cannot be overlooked by us.

I

Mendelism is the name given to the discoveries of Gregor Johann Mendel, who was born in 1822 at Heinzendorf in Austrian Silesia, entered the Augustine monastery at Altbrunn in 1843, was ordained priest in 1847, appointed abbot of the monastery in 1868, and died in 1884. From 1853 to 1868 he was teacher of natural science in the Brunn Realschule, and it was chiefly during this time that his famous discoveries were made.

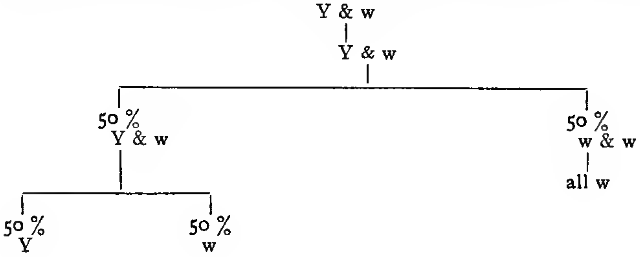
Mendel's method of research was to make a cross between organisms which differed from one another in certain definite points, to continue to breed from the hybrids thus produced and to mark the results. This method, of course, restricts the enquiry to such plants or animals as give fertile hybrids when crossed, but within these limits there is abundant room for investigation. Mendel himself made his experiments with plants, but similar experiments with animals have given the same results, so that his conclusions may be safely stated in the most general way.

Those living organisms which give fertile offspring when crossed must very closely resemble one another. But they are not exactly the same; there are certain distinguishable and separable characters which belong to one and not to the other, and which make the distinction between them. Mendel found that these characters or the greater number of them might be arranged in pairs, and it is to the behaviour of these pairs when a cross is made that his discoveries relate.

As an example of a pair of Mendelian characters we may take white Indian corn and yellow Indian corn. When a cross is made between the flowers of a white and of a yellow plant the resulting grain is yellow. In the hybrid one of the characters has entirely disappeared, and it exactly resembles one of its parents. The result is the same whether the yellow parent is the male or the female; the yellow always prevails over the white. This does not always happen when crosses are made. The hybrid sometimes shows a mixture of the parental characters and sometimes something different. But Mendel's theories are most easily demonstrated when one character prevails, and this is what most commonly happens, and therefore we shall keep to this case for the present. The character which prevails is called *dominant* and the other *recessive.* In the Indian corn yellow is dominant and white recessive.

The recessive character, however, although it does not appear in the hybrid, yet exists there in a latent condition ready to show itself when occasion offers; what happens when the cross is made is this—a germ cell from one parent unites with a germ cell from the other parent to make a new individual. Now the germ cell can only contain one member of the pair of characters ; it cannot have both. The characters behave as if they depended on the presence or absence of something, in the present instance as if yellowness depended on the presence of something by which it was caused while whiteness arose from the absence of this thing. Now in the germ cell this ingredient may be present or absent, in the individual which is formed by the union of two cells one of which contains this ingredient and the other does not, it will also be present ; but of the germ cells which this individual will come to contain, some will have it and some will not. If the two germ cells were exactly equal in power then half of the germ cells produced by the hybrid will be yellow and half will be white. This is the first point in Mendel's theory. We have now to see how it is proved to be true.

White, it will be remembered, is the recessive colour ; yellow is the dominant. Now if the flowers of the hybrid are not allowed to pollinate themselves but are made to produce seed with the flowers of pure white corn, then, if half of the germ cells are yellow, when these are united with pure white germ cells the result should be yellow seeds. The other half of the germ cells being white when they are united with white germ cells the result should be white seeds. Thus if Mendel's theory is true half the seeds resulting from this experiment should be yellow and half white, and so it turns out when the thing is tried. Moreover, the yellow seeds should be of the same character as the original hybrid and give the same result when their flowers are again united with the flowers of the white corn, and this also happens. This result may be expressed in the form of a diagram, using a capital Y for yellow, because it is the dominant character,

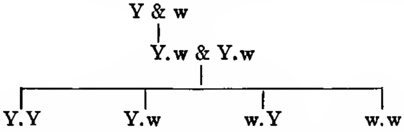


and a small w for white, because it is recessive. By & is signified united with that is fertilised by or fertilising. The first Y & w are the parents. They are pure yellow and pure white. The second Y is the hybrid which is united with pure white to make the next generation, as has been already explained.

Now what will happen if the hybrid plants are made to fertilise one another? In the hybrids there are equal numbers of white and yellow germ cells and equal numbers of male and female germ cells, there are therefore four possible cases—Yf. & Ym., giving yellow grains; Yf. & wm., giving yellow grains; wf. & Ym., giving yellow grains; and wf. & wm., giving white grains. There will thus be three yellow grains to one white, and of the yellow grains one will contain nothing but yellow, and if such grains are bred together nothing but yellow will result, while two will be like the hybrid from which they are derived, and if such are bred together will give the same result, namely, three yellow and one white. The white grain is pure white and will breed true. To put this as a formula we have—

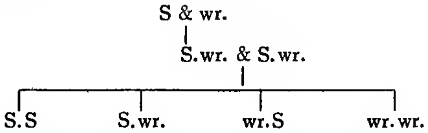
1 Y 2 Y.w 1 w

that is one pure dominant, two of a hybrid character, and one pure recessive. Or the whole thing may be expressed thus—



Y & w means as before, pure yellow fertilised by or fertilising pure white, while Y.w means a hybrid individual containing both yellow and white germ cells. Then in the lower row Y.Y means a pure yellow formed from two yellow germ cells, and w.w a pure white formed from two white ones, while Y.w, w.Y mean individuals of a hybrid character as before. Of course, these results cannot be expected with numerical accuracy when the experiment is made with only a few flowers, but when considerable numbers are dealt with the regularity of the results is very great.

Now suppose we take another pair of characters and see what will happen with them. Some varieties of Indian corn have smooth grains and some have wrinkled, and when they are cross-bred the smooth character is dominant. Therefore we write S for smooth and wr. for wrinkled, and set out the results of a cross as before.



Here S.S and wr.wr. will breed true and S.wr. and wr.S will repeat the results obtained from S.wr. above and set out in this line.

Now what will happen if we cross a smooth yellow kind of Indian corn with a wrinkled white kind ? We shall have—

S.Y & wr.w
S.Y.wr.w.

The hybrid will contain the four characters, but as S and Y are dominant it will have a smooth yellow appearance. But how are the four characters thus united distributed in the germ cells of the hybrid ? As the two members of one pair of characters cannot occur in the same germ cell there are just four possible combinations and these occur in equal numbers, that is to say, in a large number of seeds there is a very close approach to numerical equality. This is proved by breeding the hybrid with the wrinkled white kind from which it was derived. As both the quality of being wrinkled and the quality of being white are recessive, this will show the true character of the germ cells. Let us set down the four possible combinations and put wrinkled white under each—

S.Y	S.w	wr.Y	wr.w
wr.w	wr.w	wr.w	wr.w

The seeds which are the result of these combinations will, it is evident, show the characters of the germ cells of the hybrid. By counting them the truth of the theory is seen.

Now what will be the result if the hybrid is made to fertilise itself ? As there are four kinds of germ cells when these are combined in pairs there will be sixteen varieties amongst the new individuals. These may be most clearly set out in a table.

	S.Y	S.w	wr.Y	wr.w
S.Y	S.Y.S.Y	S.w.S.Y	wr.Y.S.Y	wr.w.S.Y
S.w	S.Y.S.w	S.w.S.w	wr.Y.S.w	wr.w.S.w
wr.Y	S.Y.wr.Y	Sw.wr.Y	wr.Y.wr.Y	wr.w.wr.Y
wr.w	S.Y.wr.w	S.w.wr.w	wr.Y.wr.w	wr.w.wr.w

By putting the four possible combinations to be found in a germ cell above and at the side of the table we can make the sixteen squares of the table give us the sixteen combinations which may occur in an individual. Now first let us ask what appearance they will have. If we pick out all the individuals which have both dominant characters we shall get S.Y.S.Y ; S.w.S.Y ; wr.Y.S.Y ; wr.w.S.Y ; S.Y.S.w ; wr.Y.S.w ; S.Y.wr.Y ; S.w.-wr.Y ; S.Y.wr.w. These nine will present a smooth yellow appearance. Next we have three containing S only—S.w.S.w ; wr.w.S.w ; S.w.wr.w. These will be smooth white. Then we have three containing Y only—wr.Y.wr.Y ; wr.w.wr.Y ; wr.Y.wr.w. These will be wrinkled yellow. Lastly, we have one which contains neither dominant—wr.w.wr.w. This will evidently be wrinkled white. Thus the appearance of the individuals resulting from this experiment will represent the four possible combinations of character in the germ cell in the proportions of 9 : 3 : 3 : 1. That is, nine will be smooth yellow, three smooth white, three wrinkled yellow, and one wrinkled white. This is a Mendelian formula of great importance.

To understand its importance we have only to take the diagonal which runs from the upper left to the lower right corner. On it we find four forms, all of which will breed true—S.Y.S.Y ; S.w.S.w ; wr.Y.wr.Y ; wr.w.wr.w. They will breed true because they are formed from two similar germ cells and contain no possibility of any contradiction arising when they are self-fertilised, for they have only one member of each pair of characters. Two of these resemble the original parents, but two of them are new, namely, S.w.S.w ; wr.Y.wr.Y. All the others are of a hybrid character, and it is in the certainty which we have of finding these new types that the practical importance of Mendel's discovery lies. It will be seen by inspecting that table that if these two which are now the new forms had been the original parents, then those which are now the original parents would have appeared as new forms. Thus it is evident that if two varieties of the same plant have two different Mendelian characters which it is desirable to unite in one individual it can be done with certainty. If the two characters which are to be united are recessive we shall find what we are looking for as the result of the second sowing; if one of the characters is dominant and one recessive then what we want will be accompanied by two others of a similar appearance, while if both are dominant it will be one of nine, and in these cases a third sowing will be necessary. The form that is wanted will be distinguished as that which breeds true. The same rule applies in the case of animals in which certain qualities may be desired.

As an example of the practical application of Mendel's laws the case of wheat may be mentioned. American varieties of wheat possess a quality which the bakers call strength and which is greatly valued. No English wheat has this quality, and most American wheats lose it when grown here. Some American wheats do retain this property, but they yield a small crop and are therefore unprofitable. Now upon trial made it was found that the quality of strength possessed by the American imported wheat and the quality of yielding a large crop possessed by the English wheat were Mendelian characters, which could be combined in the way explained by the table of sixteen squares, and this being done a new variety was obtained which will be much more advantageous to the farmer than anything before available.

Up to this we have only had to consider cases in which two pairs of Mendelian characters were found to be quite independent of one another. We must now consider one case in which the characters are not independent. A certain kind of pea, the seeds of which have a grey skin or integument, was crossed with another having white seeds. The seeds of the resulting hybrid had bright purple spots on a grey ground. When they were self-fertilised the result gave seeds of three kinds in the proportion—nine purple spotted, three grey, four white. The explanation of this result is that one of the characters concerned cannot show itself alone, but must have another to act on. Let us call them G, grey, and g, the absence of grey ; P, something that puts purple spots on G, but in the absence of G cannot do anything, and p, the absence of P. Now setting these out in the table of sixteen squares, we have—

	G.P	G.p	g.P	g.p
G.P	G.P.G.P	G.p.G.P	g.P.G.P	g.p.G.P
G.p	G.P.G.p	G.p.G.p	g.P.G.p	g.p.G.p
g.P	G.P.g.P	G.p.g.P	g.P.g.P	g.p.g.P
g.p	G.P.g.p	G.p.g.p	g.P.g.p	g.p.g.p

Now here we have as before nine which contain both dominants G and P, and these will have purple spots on a grey background, three which have one dominant G, but not the other, and these will be grey ; three which contain the dominant P, but without G, and these as in them the P has nothing to work on will be white like the remaining individual which contains neither dominant. Thus the proportions 9 : 3 : 4 are explained. It may be remarked that as one of the individuals containing P only, namely, g.P.g.P, will breed true the quality P might be borne by the plant for an indefinite time in a latent condition, and until G had been introduced its existence would never be suspected.

This sketch of Mendel's discoveries is sufficient for our purpose. If any reader wishes for more he will find a very interesting account of the matter without too many technical terms in the book named in the note.[1] Our interest lies in the fact that Mendel has not shown any way by which an organism may take a step forward or get on towards a higher plane of existence ; but he has shown how the possibilities which are contained in the plan of an organism may be brought out, how all that is possible may be made of it. There is nothing there-

[1] *Recent Progress in the Study of Variation, Heredity and Evolution.* By Robert Heath Lock, M.A.

fore in any Mendelian combination which can supply any indication of design, but there is a great deal in his discovery to help us to realise the distinction between the two kinds of change—that which goes on without change of level and which arises from the characters which organisms already possess, and from their chance encounters, and that which has an upward tendency and marks an addition to the design of the organism, in fact, the coming in of a new plan. It is very interesting to learn from Mendel what a vast amount of change is possible without any advance in the course of evolution.

II

If Mendel has shown us how the characters already existing in living organisms may be variously combined, de Vries has discovered what at first sight looks very like the acquisition of a new character. Let us first see what the facts are. We can then consider what may be deduced from them.

Near the town of Hilversum in Holland, de Vries found a plant which was undergoing what he has called mutation. Some plants of the species, *Œnothera Lamarckiana,* or Evening Primrose, which had made their escape from a garden into a disused potato field, were there running wild, and amongst them he discovered two forms which seemed worthy of being called new species. On taking seeds from these and sowing them in his garden he found that they bred true. He then transplanted roots from the field into his garden and also raised plants from the seeds of the original species until he had grown a vast number of plants and culivated some of them for several generations. The result was that about 1½ per cent or possibly rather more of his seedlings showed some mutation, giving him fifteen new recognisable species. These new species also showed in many cases a tendency to mutate, but not to the same degree as the original species from which de Vries rather hastily drew the conclusion that in the life of a species a period of mutation is followed by a period of stability.

What gives these new forms their chief interest is that they were not built up gradually, but showed themselves suddenly, and that having once appeared they bred true. If there is any exception to the suddenness of their appearing it lies in the fact that some of the new forms were not fully manifested for some generations, but when they showed themselves first, presented an appearance intermediate between the new form and the parent. But in every succeeding generation they made rapid approaches to the new form in which before long they settled down. There was not in any case a series of slow much less of imperceptible changes in passing from one form to the other ; it seemed as though Nature had made a leap.

De Vries' experiments have been repeated by others who have obtained all his results and others like them besides and have even obtained a greater percentage of mutations than de Vries himself. Cases of mutation have also been alleged to occur in other species. Nothing has, however, been really added to what de Vries observed, and the mutations of *Œnothera Lamarckiana* are the most striking and the best series that can as yet be produced.

The amount or degree of variation to which the name mutation has been given is defined by de Vries as a change not in a single character, but in a set of characters—such a change as is sufficient to constitute a new species. Mutation is understood to be the sudden appearance of a new species. But species are not given the same boundaries by all naturalists. Linnæus gave his species wide boundaries, and advised naturalists to ignore trifling distinctions. After him came Jordan, who marked out narrower limits for a species and took account of less important differences. He divided all the species which Linnæus had described, making in one case two hundred of his out of one Linnæan species. De Vries' new species are of Jordan's, not of Linnæus' kind.

This is a matter of some importance when we come to the interpretation of the facts.[1] The interest which they have excited amongst naturalists is due to their bearing on the origin of species. Much of the difficulty felt about Darwin's theory arose from the necessity of supposing that all changes came about by insensible degrees. It was not easy to see how an insensible degree of any quality could be of so great importance as to influence Natural Selection. If everything depends on the survival of the fittest, surely something more than imperceptible degrees of superiority must constitute the fitness of the survivor. The new discovery shows a way out of the difficulty. It is not necessary to suppose that all changes come about by insensible degrees. A new species breeding true, able to maintain itself, and showing such differences from the original stock as might easily be supposed to tell in the struggle for existence may arise in the course of a single generation.

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[1] The book recommended in the first part of this note may be consulted for further information as to de Vries' discoveries.

But then when we go on to ask whether the new species thus arising shows any progress in the scale of being, any signs of rising above the level of the parent species, any addition to its plan, the answer is not so satisfactory. The new species stands on the same level as the old. All the changes which are shown might be due to such shiftings and changings in the constitution of the species as are consistent with its plan, and are caused by chance encounters with such things as may influence it in its surroundings. If they constitute new species of Jordan's making they all remain within the bounds of one of the Linnæan type. There is change on the same level, but no mounting a step and attaining to a higher level. It is quite conceivable that a long course of mutations, starting from *Œnothera Lamarckiana*, might in the end return to *Œnothera Lamarckiana* again. And this view of the mutations is confirmed when we hear that de Vries' experiments have been repeated by others and the same results obtained. When experiments can be repeated and the results predicted it is evident that we are not dealing with the occurrence of anything new. What we have before us is the result of manipulating the constant and settled properties of objects which give a similar reaction to similar surroundings. If the same species appears twice as the result of different mutations (and some have appeared more than fifty times), then we know that it is really there all the time and only waiting for suitable conditions to show itself. It is then part of the plan already belonging to the organism, not a new thing now for the first time added to it.

This view of the nature of the mutations is not very different from de Vries' own speculations, for he thinks that the new characters which they exhibit are already existing in the parent species in a latent condition. But he has a theory as to how they came to be there which it is not easy to accept. The species he thinks has a period of mutation followed by a long period of stability. During the period of stability, by the action of the environment or otherwise, the new forms come gradually into existence, but in a latent state, and when the time of mutation comes they are produced. This way of accounting for them would deprive the mutations of their chief interest. They were welcomed because it was found impossible to think of new forms as arising by the natural selection of insensible differences, but this theory requires us to think of them as arising from the accumulation of differences not merely insensible in degree, but not in any way manifested, and that without the assistance of natural selection. Moreover, as the mutation of *O. Lamarckiana*, together with the mutations arising from those mutations, give between twenty and thirty distinct forms, we have to imagine all these produced simultaneously and side by side by the action of the one environment on the one species, all coming to a head together and all produced in one period of mutation as soon as they were fully formed. It is not a theory which helps us very much to understand how these things come about.

It would perhaps be better to abstain at present from forming theories. The facts are very curious and very interesting, and may be full of instruction when we come to understand them better. But while we may hope for new light on the variations which may be implicitly contained in the plan of a species and the conditions which will bring them out, we have nothing which would lead us to expect from this source any new knowledge about the manner of the great advance from a simpler to a more complex organisation which the course of evolution shows.

Least of all can we see here any least hint or suggestion of a plan for making the impulse which comes from the past do the work of the foresight which looks to the future.

PART II

A MORE ABSTRACT OR PHILOSOPHICAL ARGUMENT

CHAPTER IX

NECESSITY

Up to this our argument has kept fairly within the bounds of ordinary common sense. And for a practical question which bears on everyday life and conduct this treatment ought to be sufficient. The irresistible convictions on which common-sense views are, in general, based have ever been the infallible guides of the human race in so far as its action has been controlled by intelligence and will. For practical purposes it can never be necessary to ask for other guides or better. Nor will most people be disposed to push their enquiries farther, for to do that is to enter the arid regions of abstract thought, through which there are but few who care to wander. Yet for the sake of those few, and on account of the effect which their complaints might have on the minds of others, if they found themselves neglected, it is necessary now to take their point of view and consider the question as seen from it.

When thus considered the first thing that comes into view is a stern and all-embracing necessity which threatens to destroy the whole edifice that we have been laboriously erecting. There is really, we are told, no such thing as chance except as a name for our ignorance. Everything is determined by what has gone before, and nothing could be other than it is. We need not try to hold the balance even and decide between chance and design; necessity sweeps them both away and leaves no room for anything but itself. Whatever happens must have a cause. This cause must be something which was in existence before the event. It must completely determine the event, for if it did not there would be something without a cause, and therefore unaccounted for. If we knew fully the causes of any event we could calculate accurately what the event must be. And if we knew fully the causes of these causes we could calculate accurately what they must be. An intelligent being, capable of knowing the positions, motions, qualities and forces of all the particles in the cosmic mist or diffused nebula from which the universe sprang, might be supposed to calculate its future from these data, and to predict the condition and place at any time of any given particle. Such a prediction would only differ by its great complexity from those which astronomers make when they construct tables which show the motions of the planets, the occurrence of eclipses and other astronomical events. If its complexity did not make it impossible it would be as regularly calculated and as accurately fulfilled.

The necessity here alleged is physical necessity, the causation which is mentioned is physical causation. The principle of physical causation is a result of our ideas of matter and force. When we analyse our ideas of material things, as far as we possibly can, we get down at last to matter and force. These two cannot be thought of or defined separately, yet they are two very distinct ideas on which all our thinking about the world around us is based. Matter is regarded as the basis or repository of force, and force is the influence which one material thing has on another. We cannot think of matter except as a collection of material particles, influencing one another by various forces. The essential property of matter is inertia, the essential nature of force is to make a change in matter. Neither matter nor force has any spontaneity or freedom. Matter can make no change in itself, but can only yield to force; while force has no choice whether to act or not, or how or where or when to act, but always must act wherever it may happen to be. Matter is inert and force is blind, and all their action and interaction is therefore subject to inevitable necessity. This is the doctrine on which physical science is based, and which is supposed to overturn our argument about chance and design.

It is a true doctrine and quite able to support all the conclusions which physical science draws from it, but it does not in any way interfere with our argument. To make it overturn our argument another doctrine must be added to it, namely, that physical causation is the only causation, or to put it another way, that matter and force are the sum total of existence. But our argument is in effect an argument to show that physical causation is not the only causation, and that something exists besides matter and material force. We have put our argument in a common-sense way, and have shown that we have an invincible conviction that something does exist besides material substance and material force. We have brought forward many instances of form and arrangement which we are wholly unable to ascribe to the action of matter and force if left to themselves. We have used the word chance to express this action of matter and force alone, or apart from mind and purpose, and we have shown that it is quite impossible to ascribe everything in the world to chance. And we may add that as there is something else in the world, some other element in the bringing about of events, besides mere physical causation, the supposed calculation of events from their mere physical antecedents would not always and everywhere be successful. We find then in the objection that has been made a mere and bare assertion that nothing exists besides matter and material force, an assertion which our argument has taught us to disregard.

But here we may be met by the view that the idea of necessity upsets our argument in another way. For we had four things before us, order, confusion, mind and chance, and our decision was that order always implies mind, and that chance can only bring about confusion.

Now physical necessity it is said, which is not mind and which does not imply mind or purpose, produces a calculable and regular result, that is to say, brings about order, not confusion.

I have put the objection in this form because I have noticed that many people imagine that any process which can be calculated, or which may be supposed to be such as could be calculated, must have a regular and orderly result. But let us suppose a number of things lying in disorder and confusion. Surely it is plain that they might pass from that state of disorder and confusion to another state of disorder and confusion by a process of physical causation which might be supposed to be capable of calculation. Suppose a set of printer's types not set in any order, but lying in confusion on a table, and suppose the table upset and the types scattered on the floor, would they not pass from one state of confusion to another state of confusion by a strictly physical process? And would it put any order into their condition, that the physical process might be considered to consist of a series of impacts, each having a definite character, and a definite and necessary result, which might be calculated by a being possessing sufficient skill and supplied with the necessary data? The fact is that physical causation does not enable us to go back to the beginnings of things. It is merely a handing on of force received. The force passes on in a necessary way, carrying with it order or disorder as the case may be, but not originating anything. When we set things in order physical necessity is the basis on which we rely to accept and preserve that order. The watch with which our argument began is an example of order and design, but it is none the less an instance of physical necessity. If the watch is broken up and its parts scattered in confusion, or if it is melted down into one mass of metal, the design is lost, but physical necessity still prevails. And the watch, while it remains a watch, moves and works and exhibits our design just because all its motions are determined by physical necessity. We cannot regard necessity as anything more than a quality or condition of material things which makes them fit to be in a state of order or a state of confusion, to exhibit a design or to show the absence of any.

Physical causation may preserve and transmit a design, but it cannot increase it or add anything to its complexity. It follows from the very idea of causation that the cause cannot give out anything more than is in it, and, therefore, what it does not contain in the way of design it cannot produce. If it did produce a more complex design than it sprang from we would have something without a cause. And hence the supposed simple and evenly diffused original nebula could not have contained the designs of plants and animals. These are elaborate systems of material particles, complicated and delicate machines. To suppose them to arise from evenly diffused matter is to suppose a design to spring up of itself—something to come into existence without a cause. The principle of causation forbids us to suppose that any such thing could occur.

Physical causation admits of chance in the meeting of different causal series. We may suppose one series set going and think of it as acting under strict necessity, and another series as set going and continuing in the same way; but if their meeting has not been thought of beforehand and provided for, when it happens the result is an instance of what we call chance, and such chances produce confusion. A clock outside a shop is an example of design, and so is the system or organisation of a horse; but if the clock falls on the horse we have, when they meet, something not provided for in either design, and which consequently has a tendency to destroy both. This is an instance in which chance brings confusion. If everything is not foreseen and provided for at the first, then what is not provided for is left to chance, and when it comes the necessary chain of physical causes will not make it anything else than chance or mitigate the confusion which will ensue. It is not enough to provide a number of necessary causal series at the beginning. Their mutual arrangement and co-ordination must also be provided for. And this demands foresight, and is the work of mind.

Moreover, if we could suppose the designs of plants and animals to be contained in the positions and motions of particles in the primitive nebula, we have to take into account that the nebular theory supposes that every planet was at first a molten mass, and we know that the seeds, or spores, or other small bodies which carry the plans of plants and animals, consist of particles of matter having a more elaborate structure and arrangement than is possible for the particles of molten matter. The designs, if they had existed before, would of necessity be destroyed when entering the molten state, and hence all the organisation and plan which we see in plants and animals must have arisen since the earth was in a molten state, and from matter whose particles were in a simple and unorganised condition. Now, if the complicated organisation was produced by the action of mind it has a cause, but if it arose by chance, that is, without mind or design, it has none, and so we must either admit that the world shows the action of mind and reveals a purpose, or else admit that something has happened without a cause.

The idea of necessity, then, does not in any way remove the alternative of design or chance, nor does it tend to throw any doubt on the validity of our common-sense argument. On the contrary, it rather assists it.

CHAPTER X

CHANCE

THE philosophically minded reader who has followed our argument thus far will now expect a more exact enquiry into the nature and implications of Chance. The word has been consistently used for the absence of plan or design, so that material bodies, however they may be moved and by whatever laws they may be governed, if they are not moved according to the design of a superintending mind, are said to be moved by chance and their motion, we have held, must in that case tend to confusion. But our reader has heard of books on the theory of Chance treated either mathematically or philosophically, perhaps he may have read them. In any case he knows that what they educe from chance is not confusion, but a certain kind of order which may be anticipated and made the subject of calculation, and he will expect that the relation between chance as it has been presented in this argument, and chance as it is presented in these books shall be cleared up.

There is really something here that needs to be explained, because utter confusion would evidently not admit of calculation. Where there is a calculated result there must certainly be some measure of order, and if it is the result of chance which is calculated, then chance seems at least at first sight to be capable of producing order. And if this is so our argument evidently fails. But when we ask particularly what these mathematical and logical books mean by chance we find that they invariably contemplate a *series*. It may be a series of events or a group or class of objects which is capable of being treated as a series, and which has always certain regular and orderly properties. And on contemplating this series order is found gradually emerging out of disorder, and showing in time a marked and unmistakable uniformity.[1] The reason is that the individuals which constitute the series, whether individual events or individual objects, are compound, each being made up of collections of things or attributes, some of which exist in all the members of the series, while others are found in some only. And the distinctive characteristic of the series which makes it a proper subject for calculation, and is the true explanation of the kind of order which is found in it, is that the occasional attributes as distinguished from the permanent are found on an extended examination to exist *in a certain definite proportion of the whole number of cases.*[2] But this shows us that what the theory of chance contemplates is not *pure chance* but what we may call *limited chance,* or a mixture of chance and order. The order which the series shows in the long run has been in it from the beginning. It is only obscured but not overcome by the chance which produces the irregularity or confusion which the series shows at first. In order to fit it for calculation, the series must show the special attribute which is the subject of calculation *in a certain definite proportion of the whole number of cases.* Now this never happens by chance, it never could happen by chance. The series, moreover, apart from its differences, must be a regular series, and this, too, could never come about by chance. Thus the series on which the logical and mathematical theory of chances is based shows in two ways an order by which its chance is limited: first, as it is a real series, and secondly, as some peculiarity attaches itself to a definite proportion of the members of the series. It is no wonder that with so much order it is found possible to analyse the series both ways, when the rule is given finding the results which will ensue, and when the results are given finding the rule by which the series is constructed.

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[1] Venn's *Logic of Chance,* chap. I, § 10.
[2] *Op. cit.,* chap. I, § 6.

Some of the series contemplated by the theory of chance are natural and some are artificial. As an example of such a series it is usual to take an artificial one because its structure and character may be more easily shown than in the case of natural series. We shall take as an instance the series formed by a succession of throws with two dice. No series can be found which exhibits the characteristics of limited chance more clearly or within a more convenient compass. The series is a regular uniform series because it is the successive throws made with two dice. It has certain qualities attached to a definite proportion of cases, because each of the thirty-six possible throws occurs, on the whole, the same number of times, and the longer we go on throwing the more clearly is this regularity shown. Here we have, then, the combination of individual irregularity with collective regularity, which is so striking a feature of limited chance. There is individual irregularity, for it is impossible to guess what any particular throw will be, and there is collective regularity because it is possible to anticipate with great confidence the result of a large number of throws.

All this arises from the fact that at each throw of the dice any one of the thirty-six possible combinations is just as likely to turn up as any other. All have, as we say, equal chances, and in the long run each of them will turn up the same number of times. But if we ask how this series is provided, we shall see that the method by which it is brought about involves a little confusion and a great deal of order, that is to say, a little chance and a great deal of design. There are probably very few persons who have ever realised how much design and how little chance there is in the familiar pair of dice and the manner of using them.

In the first place we provide a dice-box which is an evident instance of design, being expressly constructed for the purpose of casting dice. Neither the provision of the box nor its character is left to chance. If they were it may be doubted whether anything would turn up, but we may be quite certain that if anything did turn up it would not be a dice-box. Then we don't leave it to chance whether there shall be anything in the dice-box or how many things shall be in it, but we put in two dice. If we left it to chance there might be nothing in it or it might contain a fly or a pebble, but certainly we would not expect to find it containing dice. The dice themselves are evidently designed and carefully made so as to show six faces numbered from one to six, and all exactly even, that there may be no greater chance that the die shall come to rest on any one side than on any other. And we do not leave it to chance what shall happen then, but we shake the dice in the box in the customary way and cast them out, not anywhere as it may happen but on a flat surface where they may come to rest with one side turned up. Now think for one moment of the endless myriads of chances excluded by the design which is shown at every step. Think of all that might have happened but is prevented from happening by something in the design, and the thirty-six chances that remain will seem but a very trifle in the way of chance as compared with such a vast quantity of design. And yet this is not all, for now we enter on a new series of limitations in which design is shown, not by taking means to prevent a certain thing from happening but by ruling it out when it happens. There are the usual thirty-six throws shown when the dice lie side by side. But there are thirty-six others which occur when one die stands upon the other. These do not come often, but they come occasionally and they might have been used and might even have had some peculiar value in the game. But it is more convenient to rule them out and to let the throw be made again. There are also times when one die is propped against the other, so as to have an edge instead of a side uppermost, and these also are ruled out.

Thus a great many chances have been removed by counting out unsuitable results, and yet many though they are, they are as nothing to those which we come to now. When the dice lie on the table showing two numbers one may lie north of the other or south, or towards any other point of the compass. The circumference of a circle may be divided into an infinite number of parts, each giving a different direction, so that here we have an infinite number of different results, none of which is taken into account. Moreover, each die may present to the other a side or edge, it may, in fact, revolve in a circle assuming an infinity of positions relative to the other. Here are two infinities excluded from the result. And, again, the distance between the dice may vary within certain limits, giving an infinite number of possible distances, all of which are neglected. None of these chances is of the least importance for the purpose for which dice are used, but if it were a question of forces, impacts and directions of movement these would be the more important considerations and the numbers displayed by the faces of the dice might be neglected. So that here again we find that the number of possible throws is reduced to thirty-six by the action of mind, by deliberate choice, purpose and contrivance, by the exclusion of infinities of chances which otherwise might come in and the ignoring of infinities of chances which do, in fact, come in.

Some of the points which have just been put may seem to be trivial, but they are not really so because the end in view is to show that the kind of chance which can be calculated and expected is limited chance, and that its limitation is no trifling matter but amounts in every case to the exclusion of unknown infinities of chances and the retention of only a few. Nor can it be argued that many of the chances thus excluded are of no importance, for nothing is of any importance except with regard to some purpose, design or foreseen result, so that when we begin to talk of the importance of things we bring in mind and purpose, and have regard to what comes next. But chance cannot be supposed to be in any way influenced by what comes next.

We are able from this example to see that what is calculated is not the chance but the order that limits it. It is the limitation which gives each of the possible results an equal possibility of occurring, that is the foundation of the calculation. But equality of opportunity is essentially order, not chance, and the necessity of filling up an unlimited number of throws with a definite number of possible results is order, not chance. All that is really left to chance is the result which will follow upon any given trial, and that is not in any way a subject for calculation ; confusion reigns in particulars but order prevails in the long run. And we are able to see how chance comes in where the guidance of mind and purpose is withdrawn. The process of throwing the dice is so contrived that it is impossible to co-ordinate the action of throwing them with the result expected or wished for. The shaking which the dice get brings about the position into which they fall, but it is impossible to make it have any relation to the position into which you would like them to fall. He who holds them in the box cannot give them any guidance or subject them to control. The chances of dice throwing, the uncertainties which are part of it, are altogether owing to the absence of design or mental action. We have here a clear illustration of both sides of the axiom which has been so often laid down : Order implies mind, but chance means confusion.

CHAPTER XI

UNLIMITED CHANCE

WE have seen that chance as it is commonly expounded in treatises on the Theory of Chance, whether Mathematical or Logical, is not pure chance but limited, and that the theory as it is taught might be more properly termed the theory of the limitations of chance or the theory of the combination of chance and order. What the theory is concerned with is to show that the order is there although masked by the chance with which it is combined, and to teach us how to find what the order is, and how to show that it will prevail in the long run. Where the theory is defective is that it fails to note that while order may limit chance, chance can add nothing to order, it may not, it does not always, destroy the order with which it is combined, but it never increases it, makes it more complex or raises it to a higher degree.

With a view to bringing the true nature of chance into greater prominence and of more clearly understanding what may be expected from it we ought to take a step beyond the limits of the subject, as discussed in the treatises we have mentioned, and try to get some notion of pure or unlimited chance. The mere attempt, whatever other results it may have, will bring more clearly into sight that side of the subject which has been most neglected.

It will at once appear to anyone who makes this attempt that pure or unlimited chance is rather an ideal to be more or less closely approached than a thing which we may command at will or discover by an easy search. In fact, an event happening by pure or unlimited chance is exactly in the same position as a machine without friction or a perfectly rigid bar, and for the same reason. Machines and bars must be constructed out of such materials as we find existing and, therefore, cannot be divested of friction or elasticity, and in like manner events must happen amongst the things which exist and, therefore, cannot be altogether divested of order. The whole nature of things is permeated by order and regularity, and, therefore, cannot anywhere admit of chance without at least some limitation. But although frictionless machines and rigid rods cannot be exhibited, it is found that to discuss their properties is not without utility, and so it will be found to be the case with a discussion of the properties of pure chance.

What we want, of course, is to exhibit the relation of chance to order, and for this purpose we would like to get something wholly without order and make it subject to chance, and then observe the result. But anything wholly without order is not to be found. When we split up matter into the smallest parts that we can get at we find that they have definite characters and peculiar properties, and fall into certain distinct classes. And when they are brought together they have certain definite effects upon each other and are found to obey certain laws and, in fact, to have a great deal of order in their very constitution. And so we have everywhere a certain amount or degree of order which can never be got rid of.

We accept our limitations and give up the idea of exhibiting an instance of pure or unlimited chance. But we observe that there are lower and higher degrees of order and that it is the lower kind of order which is universally diffused, and from which we can by no means anywhere escape. The higher kinds of order are exhibited by more complex arrangements of parts, require a more elaborate system of relations between them and, in particular cases, may not exist or may be destroyed. We cannot get rid of that property of matter by which it is subject to gravitation, and this always imposes a certain order and arrangement upon everything with which we can deal. But the higher kind of order shown by a machine or an animal is not inevitable. It may not exist or it may be destroyed. We may, then, accept the lower kinds of order as inevitable and experiment on the effects of chance arrangements with regard to higher kinds, and in this way see the nature of chance, and account, it may be, to ourselves for our inevitable and irresistible belief that chance cannot produce order.

If we find, as the result of this enquiry, that we are able to maintain that our belief that order cannot arise without the presence of mind or intelligence is reasonable and can be justified with respect to that sort of order which is not inseparable from all material things, then we shall insist on applying it also to that order which is part of their very nature. We shall argue with full confidence that wherever we find order and regularity we find the work of mind and have the testimony of Nature that it comes from the hand of a conscious and intelligent Being. In support of this argument we shall allege the invincible belief which we find arising whenever we think of it that order implies mind—a belief which we are compelled to follow in practice and which is a good reason for maintaining the truth of the doctrine which it supports—and also the fact that wherever and whenever it is in our power to prove it, order does arise through the influence of mind and in no other way. And we shall hope to add to these reasons some special argument based on our present enquiry which may tend to show why it is that chance cannot produce order.

Let us take as the objects to be experimented with a box of letters such as are used for spelling games and a smooth, level surface such as a dining-table. These letters are small, rectangular pieces of cardboard having each a letter printed on one side, the several letters being supplied in the proportion in which they usually occur in English words. If we scatter such letters with a fair degree of uniformity over the table we find that there is a certain order and regularity which we cannot get rid of because it belongs to the things themselves. We have the smooth, uniform surface of the table and the similar shapes and material of the cards on which the letters are printed. These impose a kind of order on every arrangement that turns up, for the cards will lie each on one side on the table, either in groups and heaps or with an equable diffusion according as we have thrown them out in one way or in another. This order we must accept and look beyond it seeking a further and higher order which may or may not be there.

Now what we want is to look beyond the inevitable degree of order which has been imposed on the cards and with regard to anything more than that in the way of arrangement to get as near as we can to pure or unlimited chance. Our best way seems to be to sprinkle the cards over the table as evenly as may be. Such equality of distribution as we give them is due, of course, to design, but we can look to the characteristics which we have not given to the arrangement and which, therefore, are the result of chance. Taking these into account the cards may lie in order or in confusion; we are therefore interested in considering what and how many they may be.

We do not in this distribution determine the particular spot on which the card shall lie or the way in which it shall lie there. But as every distinct position in which a card may lie must count, it is plain that each card has an infinite number of places which it may assume which might be determined by the distance of its centre point from the corners of the table. We must not now say that infinitesimal differences are not to be counted because, in the first place, we do not know what is the least difference that can be of importance. The importance of things does not always depend on size. Some microbes, so small as not to be visible through the most powerful microscopes, may be the causes of serious and even fatal disease, and possibly portions of matter indefinitely smaller than the microbe may be necessary to its existence. And, in the second place, if we did know what was the least difference of any real importance we could not take such a distinction into account, because if we did we would be introducing the element of design which we are trying to exclude, and going back to the consideration of limited chance instead of unlimited. We must take it, then, that one letter thrown on the table may fall into any one of an infinite number of positions, understanding by that statement that the number of possible positions is a true mathematical infinity.[1] And as in each position either the printed side or the plain side may lie uppermost, this gives us two series of infinite positions. And as in each position the card may revolve upon the centre point by which the position is determined until each corner has described a circle, this gives us an infinite number of variations for each of these positions. All this is true of each separate card, so that the total number of possible arrangements for all these cards as a whole can only be expressed as the product of all these infinite numbers when multiplied together. It will, perhaps, be conceded that with such possibilities as these we have a reasonably good approximation to true, unlimited chance. We have now to consider what sort of results may be taken to indicate order.

We shall not be able to define beforehand the sort of arrangement which may be called orderly lest any really orderly arrangement should be thus excluded. We must only say that any arrangement that shows order is to be accepted, and then consider some of the possible arrangements which would evidently show order. Such an arrangement would be the uniform spacing of the letters so that they should be scattered evenly over the whole surface of the table, and another such an arrangement would be their lying in such a way that the sides of each card should be parallel to the sides of all the others. It is evident also that in either case infinitesimal irregularities would not hinder our recognition of the arrangement as orderly. If anyone undertook to place the letters in any orderly way no doubt there would be trifling irregularities in his work, but it would be evidently orderly for all that. We could not beforehand say in a general way that any difference, however infinitesimal, should not be taken into account in the result, but yet after trial made we may pronounce some particular kind of result to have a certain character from which infinitesimal differences would not at all detract.

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[1] For the sake of any reader to whom this is a strange notion, a note on Infinite Numbers has been inserted at page 110.

There are many other possible arrangements of the letters which would be accepted as orderly. If, for instance, they were arranged in straight lines parallel to one another crossing the table in any direction whatever, or if they were arranged in squares, circles, triangles or any other regular figures the arrangement would certainly be a regular and orderly one, and of such possible arrangements many infinite series may be imagined.

But suppose the cards to be tossed out on the table in any disorderly fashion; it is evident that a line may be drawn in any direction, say, for instance, parallel to one side of the table and in such a position that half the cards shall lie to the one side of it and half the cards to the other. Now one of these parcels of cards may be taken up and laid down again in such a way as to correspond to those on the other side as their image in a mirror would do. Here we have a symmetrical and regular arrangement and one which is of great importance, because the possibility of making it proves that for every irregular or disorderly position into which the whole set of letter-cards may fall there are many corresponding regular, orderly and symmetrical positions into which it might be deliberately altered.

Symmetry is one principle of order, repetition is another, and if we laid down the cards we had taken up so as to repeat the positions of those that were left where they had fallen we would show that there is another and different series of orderly arrangements into which any disorderly arrangement might be changed. Putting the two series together it will not be doubted that for every possible disorderly and irregular arrangement of the cards there are an indefinite number of possible orderly and regular arrangements.

We are now able to justify that instinct of our intellectual nature which compels us to ascribe every instance of the production of a new orderly arrangement to the action of mind or purpose, and to deny that chance can produce anything but disorder. For as there are many orderly arrangements possible for each that is disorderly, if chance might produce anything it would be just as likely to produce order as confusion, or even more likely to produce order, and we might reasonably expect that after a few trials at the most some orderly arrangement of the whole set of letter-cards would come by chance. We can easily satisfy ourselves by actual trial whether the letter-cards, when we have thrown them out, will ever show any greater degree of order than we have actually put into them.[1] And then we shall feel that by a crucial test we have confirmed the conviction with which we receive the common-sense principle that chance never produces order.

Those who maintain that chance may produce order do not really contradict this principle, for it will always be found that when they bring forward an example or illustration they are contemplating some case of limited chance to which it does not apply. They get out of their example only just so much order as they have put into it. If they maintain that the letters which would express a poem being jumbled together in a bag may so come together again by chance as to form the poem once more, it will be found that they suppose the letters to be drawn from the bag, one at a time, and laid down in a line one after the other, the order in which they are drawn from the bag being all that is left to be determined by chance. Now this reduces the case to one of limited chance. The total number of possible results is the number of the different ways in which the letters may be arranged in a line or row. This may be an immensely large number, but it is a finite number and may be exhausted and exceeded in a finite number of trials. If, therefore, order results from such a proceeding it is merely the order which has been put into the antecedent and which shows itself in the consequent. No result from such cases as this has any bearing on the doctrine of unlimited chance.

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[1] The experiment when actually made gives a far higher degree of certainty and satisfaction than when merely considered.

But this case may in another way justify our belief that chance cannot produce order, since it enables us to see why this is so. The order which the letters are given when they are set down in a row one after the other comes from the process by which each is separately taken from the bag and laid down in its place. The amount of guidance thus given to each letter is incalculable. At every point in its journey it is ready to go wrong if the guidance fails. How far and how fatally it may go wrong will be noticed if in a moment of inattention it is allowed to drop on the floor. And when it is laid down in its place in the line the action is one which has regard to the letters already there and to those which it is intended shall follow. Surely if we never had the irresistible primary conviction that chance cannot produce order we might now accept the principle as a certain truth newly discovered simply on the ground that if the foresight and design from which order springs are withdrawn the order vanishes also. We can also see how it is that it has been often asserted that everything is bound to come at last if only a sufficient number of trials is made. Such cases as this are before the mind—cases in which the possibilities are finite. But as time supplies us with only one infinite series of moments there can be only one infinite series of trials, and where the possibilities exceed one infinite series in number time will not suffice to go through them.

The analysis and examination of our primary irresistible belief that chance cannot produce order has led us on to a more exact idea of the nature of chance. We have seen it necessary to make a distinction between pure chance and limited chance, and we have found that whenever it can be with any degree of plausibility alleged that chance may produce order it is limited chance, not pure chance, of which the assertion is made, and the order is produced not by the chance but by the order which limits it. In fact, out of any arrangement of things it is only possible to get so much order as has been already put into it.

NOTE ON INFINITE NUMBERS

To most persons, even though their minds may be naturally of a philosophical or a mathematical cast, the idea of an infinite number appears at first sight very strange and even unintelligible. Yet they will find it on consideration to be quite simple in itself and not very difficult to anyone who is not hopelessly unphilosophical or unmathematical in his mental character. It is, moreover, an idea which is found very useful in mathematics, and quite necessary for an accurate and thorough examination of the theory of chance. Perhaps a little device may make it plain to any reader to whom it may be new.

Let us just imagine that we have at our disposal a counting fairy who, being a fairy and not requiring sustenance, sleep or holidays, can go on counting for ever. Now if we suppose her once started she will evidently count on until in the course of time she has counted up to the highest number we can think of and has gone beyond it. In fact, whatever number is given her she can count up to it and exceed it and still go on counting and never cease. This gives us the idea of an infinite number. It is a number greater than any assignable number. It is not exactly a number in the ordinary sense, for any one number however great is after all only a finite number just like one or two or three. It is rather to be taken as a series, a process, a counting that goes on and on without end like the work of the counting fairy. But though it has no end it must always have a beginning. The counting fairy must begin to count and the infinite number must begin with one, two, three, and so go on to whatever length it may attain. If it is to be truly an infinite number it must go on for ever.

For so far this is not a very difficult idea, but now we come to the only point at which there can be any difficulty; when the nature of an infinite number has been so far taken in it appears to be so great that nothing can be greater. For whatever it may be that is greater is only something to be counted, and if we give the counting fairy time enough it may be counted in the long run. But then two counting fairies can count more than one and three can count more than two, and we can increase our idea of multitudes by setting many fairies to work and having many infinite series going on together. Then whatever we suppose our first fairy to do in the way of counting we suppose the others to do the same. They go on side by side and form many infinite numbers of which it is evident that one cannot be made to include the others. We may even suppose an infinite series of which every member shall be itself an infinite series, so that we shall have an infinite series squared or multiplied into itself.

Now, what use can we make of these infinite numbers? To count any things supposed to be at any moment in existence one infinite series must suffice. If we were to set our fairy to count the number of atoms in the universe we would give her a finite or limited piece of work to do. The number is, no doubt, unimaginably great, but still it is some definite number and no more, and some time or other the fairy's work would be done and she would have a rest. But if we set the fairy to count possibilities the case is different, for possibilities are not necessarily limited as things existing are and may require for their expression not merely an infinite number, but the product of many infinite numbers into one another. Now here is the utility of that conception. When we consider a series of chances, that is to say, of course, a series of limited chances, we are contemplating a series or process which may go on without end, giving thus an infinite number of trials and also many series of things which can possibly happen at each trial of which one must happen each time while the rest are lost for ever. Thus in throwing with two dice we have a process which may go on for ever, and we may consider the result of an infinite number of trials. At each trial there are thirty-six possible results, of which one happens and the rest are lost. They are no longer possible since the one has happened. Then there are again thirty-six results possible at the next trial, of which again one happens and thirty-five are lost. And so an infinite number of trials gives thirty-six infinite series of possible results, of which such results are taken as will form one infinite series and the others become impossible. That is how it appears when we look at each throw by itself, but if we regard their combinations then the total number possible will be thirty-six raised to an infinite power of which one infinite series will occur and the rest will be lost. In this case the number of things that may happen each time is limited. There are only thirty-six; we have then a limited chance, and by going on long enough we can give each of the thirty-six a good chance of turning up some time or other. If we take an infinite number of throws we can give it an infinitely good chance. But if the number of results that may occur at each trial is infinite, we cannot give any result a better chance by going on. Amongst an infinity of possible results we are lost, and have no reason for anticipating that any special result will turn up. We cannot say that by going on for a longer time we are getting any nearer to it. When chance is unlimited there is no calculation of chances. All we can do is to consider the nature of chance itself. The consideration of infinite numbers and of the possibility of having many such numbers at the same time and combining them by addition or multiplication enables us to see the distinction between pure chance and limited chance, to understand where to look for the boundary between chance and design and to see that it coincides with the boundary between confusion and order.

CHAPTER XII

THE CHANCE-PLUS-ORDER SERIES

We have now succeeded in marking the distinction between pure or unlimited chance on the one hand and the group or series in which chance and order are combined in such a way that what it shows us is chance limited by order. We have also dwelt on the nature of pure chance and we have seen that it is irregular and disorderly, and quite incapable of mimicking the result of design, of producing any order, or giving any basis or ground for a calculation or prediction. We must now consider more carefully the nature of the chance-plus-order group or series.

This is the kind of group or series which forms the subject of all mathematical or logical treatises on the theory of chance, but the way in which it is treated is generally unfortunate. Attention is commonly directed only to the basis of calculation which the series furnishes, but the series as a whole is not considered or described and hence such mistakes are possible as the taking of a pair of fair dice as a type of chance and a pair of loaded dice as a type of design. If the nature of the chance-plus-order series as a whole were grasped it would be seen that the fair and the loaded dice have equally a place in it and that they differ only in the proportions in which chance and order are combined in the series of throws which will result from their use. It will not be difficult to make this plain, and when that is done the whole subject will be pretty well cleared up.

There are three ways in which the question may be examined. We may form a plan of a series in which chance and order are united, and make the properties which we confer upon it the basis of a calculation which will show us what will come of it in the long run ; we may try to construct such a series and to make it give results such as we have calculated, or we may try to discover such series actually existing in nature. All these three methods are used, and all are good and useful, and we shall have to consider them all.

When we form a plan of a mixed series in an arbitrary way, ascribing to it such qualities as we please for the sake of working out and discerning all that is implied in it, we find at once that we may combine chance and order in very varied proportions. This has been brought out at the very beginning of this discussion, where it has been shown that an incalculable number and variety of chances have been shut out from the series produced by throwing two dice in order that only thirty-six may remain. If we pleased, some of those which have been excluded might be brought back so as to increase the play of chance, or, on the other hand, the number of chances left might be still further reduced. When the series is made to consist of the results gained by tossing a penny only two equal chances are left in. Also by loading the dice and by other contrivances we might determine more and leave less to chance, we might, in fact, leave as little as we pleased to be decided by chance. In theory, then, the chance-plus-order series may have so much order that it will approximate to a necessary series in which everything is determined and no opening left where chance may enter, or it may approximate to unlimited chance where all is left to chance and no place is reserved for order. But if we are to have a series which can be calculated and which will give us results which may be expected we must have one which contains a finite number of chances, and if we are to make the calculation the number of chances must be known.

Now the theory of chance is most easily explained by starting from a series in which we have a definite known number of chances and in which all these chances are equally probable, that is to say, will all tend to occur an equal number of times in the long run. And the number of hard questions that may be asked and the number of interesting solutions that may be found for them is so great when this aspect of chance is considered that it is quite excusable to forget that there is any other aspect. Yet a moment's consideration will show that it is by no means necessary that the chances should be equal. If they occur in any other than equal proportions, in the long run, provided only that the proportions are known, all the questions which were put and answered on the supposition of equal chances may be put and answered again with, it may be, some greater difficulty in finding the answers. The case of the loaded dice comes in here. With fair dice every side is given an equal chance, but when the dice are loaded a weight is inserted in one corner which is thus more likely to be below than above, so that four, five and six have a better chance of turning up than one, two and three. Between four, five and six there is no discrimination, they have equal chances and so have one, two and three, but the higher numbers have better chances as compared with the lower. Now, if we know how much better these chances are, we can bring them into our calculations as easily as we brought the equal chances, and so find out what combinations we may expect and what runs of luck are probable. There is less left to chance and more determined in these dice than in the ordinary fair kind, but they both equally give series of the limited chance or chance-plus-order kind. They are equally instances of the absence of thought or design from one part of the process and of its presence in another part.

But, no doubt, in the simplest case we most easily see the nature of the limited chance series, and the simplest case is that in which all the chances are equal. The principle relied on to bring out the nature of the results is that these equal chances will tend on the whole and in the long run to occur an equal number of times. Indeed, that is not so much a principle founded on the existence of equal chances as a definition or explanation of what equal chances are. But whether it is principle or definition it contains all that is needed for the complete investigation of the subject. Applying it to the case of two dice, we find that there are thirty-six results, each of which may be expected on the whole to turn up an equal number of times. It is not necessary that any one of these should turn up at any particular throw, indeed, it may be absent from a long series of throws, but if we go on for a long time the appearances of each throw will be fairly equal, and if we go on for a very long time will approximate very closely to equality. If we take thirty-six trials we shall give space for the whole set of results to appear. Each of them has a chance of appearing and an equal chance with any of the rest. That any special combination should appear is a contingency which has as much in its favour as against it. It is an equal chance. If we take thirty-six more trials there are as many more opportunities for the appearance of the special result looked for, and the chances are two to one. And we may go on and have it as high as we please. And not only so, but we shall find that the same is true of every combination of throws or run of luck that we may think of. If we go on long enough it will become first possible, then probable, then exceedingly probable, so that with a very large series we have the greatest uniformity on the whole with the greatest variety in detail. Both the chance element and the orderly element in the series are more clearly shown as the series goes on. We have then the strangest and most unlikely combinations turning up, while the proportion in which the several numbers are found in the series approximates more and more nearly to equality.

The properties of the series, then, depend both on its chance and on its order, and especially on the way in which its order limits its chance. We could not hope to make any calculation about results and their combinations if they were not each strictly limited to a certain proportion of cases. But we could as little hope to make a calculation about the series if everything else besides these results were not rigidly excluded. The series can produce nothing but the chances with which it starts and their combinations. If anything else appears a new element has come in and made it a different series. And with the coming of the new element all our calculations vanish, because they were based on the supposition that nothing of the kind would appear. It is necessary to assert this and to assert it very emphatically, because it is sometimes denied. But it is only denied through an oversight. Everything, we are told, is possible in time, and if we can only go on long enough anything may be expected to come. It is for the moment forgotten that the "everything" which is possible is every conceivable combination of the individual results which make up the series, and that this and nothing else is what may be expected to come if we go on long enough. But nothing outside the limits of the series will ever come. That was provided for when the series was established. Nothing will ever come from throwing two dice but one of the thirty-six results. Nothing will ever come of tossing a penny but repetitions of head and tail. Chance, that is to say, limited chance, cannot bring in anything new or show anything that is not already contained in the plan of the series.

The sort of thing that may be expected to happen as any chance-with-order series is worked out must depend on what we may call the law of the series, that is to say, the amount and nature of the order which is included in it. As that order may vary in amount from being only an infinitesimal part to being all but the whole of what determines the series the nature of the results must, it is evident, be equally varied and no general scheme or pattern can exist to which every series may be expected to conform. One thing only can be said, which is that there must be some law or scheme to which the series tends to conform, and that the conformity will be more evident the greater the extent of the part of the series which is open to observation. The most interesting and important series are those which are based on the law of equal tendency or equal distribution, like the series of throws which may be made with true dice, and these have been discussed and the problems arising out of them stated and answered at great length. Series which have a law of unequal distribution like the throws of unfair or loaded dice are of less interest and have been but little considered. Our concern is merely to note the general characteristic of all such series which is to present an appearance of utter confusion and uncertainty when only a few instances are taken, but to show an approximation to a law of distribution when a great many come into view. And we note, too, once more that this law is in effect a law that there shall be nothing new. Only what is put into the series will come out of it. The order which gives the series its quality of being calculable does so by excluding whatever is not in it from the first.

This is what we learn about the chance-plus-order series when we treat it theoretically by simply supposing such a series to exist, and reasoning from the properties which we have given it. But then the question arises, Can such a series exist? Can we find it or, if we do not find it, can we construct it?

Well, in the first place we can certainly construct it. The series produced by throwing dice well and carefully made is a series based on a law of equal distribution, and so is the series produced by tossing a penny. Each series fulfils the theoretical conditions and in practice gives the results which the theory requires. Of course, we understand that when they are said to fulfil the theoretical conditions it is meant that they fulfil them as closely as human constructions can ever fulfil theoretical conditions. The dice may be made so fair that we can see no inequality in them and find none in their results. If there is any microscopic inequality we neglect it since it does not hinder us from seeing our theoretical results working out in practice. The conditions of equality are, of course, that the dice shall be so shaped and made of such materials that they shall have no tendency to show one number rather than another. If they had any such tendency and we knew exactly how great it was, they would give us, as we have remarked, an example of a series based on a law of unequal distribution, but we want to begin with the simplest case and so we wish that our dice shall be fair. Then we wish to be sure that two dice when we use them together shall not influence one another, that is, that no number on either shall have any tendency to draw any number on the other with it in such a way that when one appears the other shall appear also. And, in the third place, we wish to be assured that the impulse to be communicated to the dice, by which they are to be moved and settled in some one position, shall not be co-ordinated with any special position, shall not have any particular tendency to produce it. In these three requirements we are quite satisfied. They seem to be very negative requirements, but that is merely on account of the form of expression. We often find it easier to define or explain our meaning by saying what it is not than by saying what it is, and so give a negative form to a very positive thought. In the present case we want to give the dice a movement which shall be impartially directed towards all the thirty-six possible results so that the particular result gained on each occasion shall not be determined by what mind does now or what it has done in the past. This is the real negation, the only negative we wish to insist on. There are only thirty-six possible results and nothing that is the work of mind shall choose one rather than another. The result is that we feel like geometers perfectly satisfied with our abstract reasoning and perfectly satisfied with the way it is illustrated by such constructions as we can make.

CHAPTER XIII

NATURAL GROUPS AND SERIES

ARTIFICIAL groups and series are most conveniently used for the study of the nature of chance and of its combination with order because it is easy to make a series of any character that may be desired and thus to illustrate the results that have been gained by *à priori* considerations. But to bring out anything of importance for our study we must go to Nature and ask what is there. We must find out whether there is anything there which is due to determination or to chance, or to a combination of the two, and whether there remains anything over and above which must be attributed to purpose and design.

At this point I feel that an explanation is due to the reader. I have all through consistently described chance as the absence of mind or design, and also connected chance with confusion and mind with order. And the reader may feel, notwithstanding anything that has been said in the chapter on Necessity, that this lays an obligation on me of maintaining what is asserted in the chapter on Pure Chance, that every instance of order is an instance of design and implies the presence of a conscious mind. Thus it may look like weakness that I now propose to abandon all series showing the character of strict determination or necessity and only to argue from what remains when arrangements due to necessity have been eliminated.

I do not adopt this course because I think it at all doubtful that order must always and everywhere have its origin in mind and thought, but because for the purpose of argument it is now convenient to make a distinction between the order which has been in Nature from the beginning and that of which we may find the origin or starting-point. What has been from the beginning we are inclined to take for granted. As we do not know how things are made we cannot easily enter into any detailed argument about it. We reckon it amongst the properties of things and feel that it is unreasonable to ask for an explanation of it. We might almost as well try to explain existence. And if existence must be taken as we find it and not explained, surely the necessary conditions of existence must be accepted in the same way—the order or disorder that it brings with it. This may not be satisfactory to everyone. There are, no doubt, some who think that even existence may be questioned and made to give some account of itself. And if it can the first question, no doubt, will be whether everything in it or anything in it or at the least the order and regularity in it must not be ascribed to mind. I have no doubt myself that in the beginning and from the beginning order implies mind, but I think it is well to turn away from these very difficult enquiries, more especially as they are apt to become so abstract that few can follow them. We therefore take the beginning for granted and base our reasoning on the course of events. Accordingly we set aside all determined series which appear to come from the beginning of things and look for our proofs in such new beginnings as we may find. We concentrate our attention on the springing up or the increase of order.

In order that we may be able to note the point where any regular disposition of things begins, we must first consider what are the different kinds of groups or series that we find in Nature. Like all enquiries into the course of Nature this becomes intensely interesting. It has the advantage of putting things in a new way, of setting them in another light, but we shall follow it only so far as may be necessary for our present purpose.

We find in Nature certain series which are altogether necessary or determined. Such a series is the succession of night and day. It only consists of two members, but their succession is so strictly determined that when one is present we know that the other must follow. This may be contrasted with the series formed by tossing a penny, which also consists of two members, but in which the order of succession can never be foreseen. Another natural series which is strictly determined is found in the eclipses of the Moon. This is a more complex series, showing variety in the way in which one member succeeds another, but where the causes of it are known, as they are by our present Astronomers, the series can be calculated and the eclipses predicted, and where the causes are not known, as was the case with the ancient Astronomers, the order in which the eclipses occur can be discovered by observation and future eclipses in this way predicted with perfect accuracy.

We see, then, that in the case of a necessary or determined series the possible combinations in which the members may occur are limited to a certain number, and these always come in the same order and form a cycle which may be discovered by observation. When the cycle has once been ascertained and the place which one member of the series occupies in that cycle, has been discovered, the occurrence of all other members may be easily predicted. Of this we need no better example than the eclipses of the Moon. But when the series is a chance series, although the chances have been limited by the order which has been imposed on the series to a certain definite number, yet no limits have been set to the number of their possible combinations, there is no cycle and there can be no prediction. Of this we need no better example than the tossed penny, where we have the smallest possible number of chances and yet can set no limit to the number of combinations, so that no reason can be given why the same combination should ever occur twice. This assertion may, perhaps, strike the reader as going too far, but if he thinks again he will see that if it could not be made we would have not a chance series but only a very long cycle, and that, when the order came a second time according to the reason given, we should have got into the return of the cycle and thenceforward we should be able to predict the order of the series. To see how in so limited a series as the throws of a penny the number of combinations is infinite we have only to take the throws in groups. Let us take them in threes, there will then be eight possible combinations, and when beginning the series of three throws we know that we shall have one of the eight, but which it shall be we cannot predict. We do not, then, get any nearer to the discovery of a cycle by grouping the throws in threes. If we take a larger number for our group we shall have a greater number of combinations to choose from but no greater possibility of predicting. But if we consider the result of an infinite number of throws we shall have an infinite number of combinations which, if they are actually made, will occupy an infinite series of moments of time. There will, therefore, be no reason why any combination should be repeated.

Amongst other natural series which are determined or necessary we may note the Seasons and the Tides. The Seasons form a simple series whose order is immediately evident and as easily predicted as the occurrence of day and night. The Tides are more complex, for though there is no difficulty in seeing that the series is regular and determined, yet careful and accurate observation is necessary to discover the cycle by which they may be exactly predicted. To these series may be opposed the changes of the Weather, where the succession is due to chance and cannot be predicted. Many careful observers have spent much time over the weather with the idea that it must be a determined series which could be compelled to yield up its secret by prolonged and accurate scrutiny. They have discovered, indeed, that the weather comes in pieces as it were, that is to say, that the weather for several days in succession may be so connected that while the connection lasts something of its character may be predicted, but no general weather cycle which might govern the succession of these separate portions has ever been discovered, and considering that the weather excites great interest and that a great number of observers have noted its changes for a long time it can hardly be doubted that if a cycle existed it would by this time have been found.

With these examples we might be content to pass on, assuming from henceforth that there are in Nature some series wholly determined and some which are partly chance, were it not that some philosophers have shown a strong disinclination to admit that there can be any Natural series that is not wholly determined. Such a series as that which arises from the throwing of dice or the tossing of pence will not satisfy them, because the chance element is brought into it deliberately by an act of the will. It arises from the withdrawal of the mind from the position of director so that an impulse is given to the dice with deliberate care that it shall not tend to the turning up of one number rather than another. This is something like chance as the result of design. It gives chance a certain appearance of being itself a sort of design, and raises the question how chance is to appear without being thus deliberately and of set purpose produced. The answer is not, however, difficult. If we suppose any causal series produced and set going we expect it to go on for ever. And two such series may go on side by side without touching. But if they do touch, this contact, unless it was foreseen and provided for when each series was launched into being, is a chance contact and can only result in confusion. And if they touch again afterwards we have only a second chance contact, which will have no greater tendency than the first to produce order or regularity. And if we suppose many causal series to meet from time to time we only suppose so many more occasions for bringing about irregularity and confusion. If there was not co-ordination and regularity at first it can never come in afterwards. Nor can we suppose that the causal series thus coming into contact must use up all possible combinations and thus arrive at some kind of order and regularity in the end. We have seen that even in the case of a series like the throws of a penny, containing only two members, the possible combinations can never be used up, and in most series we have a far greater number of possible results with a corresponding increase in the number of combinations. Thus we see that order or determination must exist from the beginning. If it does not exist at the beginning it cannot come in afterwards as the work of chance.

With so much explanation it will be easy to understand that most natural series are compound, not being wholly determined or wholly chance but a mixture of the two, what we have consistently called by the name of limited chance. Even when we find a determined series easily distinguished we notice not unfrequently that it is more or less affected by some chance series. Thus the tides are sometimes affected by the weather when local winds acting on local currents produce an unusually high or an unusually low tide. In fact, in Nature things have always a tendency to be more or less mixed, so that sharply determined boundaries and clear-cut classes are hard to find. The common rule is that one thing shades off into its neighbour, and that rule is displayed in most of those Natural series which have the character of determination or chance.

If from series of events we turn to groups or classes of objects, we shall find endless examples of this tendency to exhibit mixed qualities. When measurements are taken of the dimensions of the parts of animal and vegetable organised bodies, and when the relations of some dimensions to others are recorded, there always appears to be a mean about which the dimension or the relation hovers. It is as though there were a number of influences exercised on every living thing tending to affect it in many ways, and that sometimes a number of them acted together in one way and sometimes in another way, with the result of producing a variation about a mean or ordinary value to which the majority of cases approximates, although most of them deviate more or less from it, while some are found which show a great departure from the mean value. And while we cannot tell beforehand what the result will be in any particular case, we see that as results recede from the mean they become with great rapidity increasingly scarce. The measurements which have been taken of the heights of any considerable number of human beings of one race have never failed to show this characteristic very strongly. And many examinations made of the structure of particular organisms with a view to testing or supporting Darwin's theory of Natural Selection have resulted in showing all the characteristics of limited chance in the construction of these organisms. We need not spend time over a point on which much labour has been already bestowed. The Darwinists have fully proved that chance variation exists.

We must admit, then, that whatever may be done by the selection and preservation of chance variations, may accrue towards the working out of the course of evolution in some such way as Darwin asserts. We shall not be far wrong in supposing that this is at least as much as has been done by man by the selection of chance variations in the case of pigeons and of dogs. But we need not admit that it is very much more. We certainly need not admit that chance can produce anything new or additional in the way of plan or organisation. We can only grant that it may produce variations in the plan which already exists. All our arguments have tended to this point. We have shown in many ways that order does not arise by chance and we have insisted that where order exists additional higher or more complex order cannot come about by chance. We see in the world a magnificent spectacle of life developed from its first humble beginning to its present splendid results, and we ask by what sort of impulse this course of evolution was begun, by what kind of power it is maintained. The answer is that we can only think of a power in things to go on blindly under the influence of an impulse already received, to carry on and transfer that impulse, to maintain what order it may have, or possibly to lose the order and to maintain the impulse, but without any regard to the future or any power of originating anything in the way of either impulse or order. And we can think also of a power in mind and consciousness, to regard the future and to provide for it, and to begin a new order where there was no order before. Beyond these two aspects there is nothing, no coherent thought, no real meaning, only a talking of streams of life and waves of impulse, of the development of possibilities and fulfilling of destinies, all which talk if it is dissected and examined proves to be merely the putting of words together in such a way as to represent no real thought that can enter into any human mind.

PART III

THE APPLICATION OF THE ARGUMENT

CHAPTER XIV

THE FERTILISATION OF THE CUCKOO-PINT AND OF THE ARISTOLOCHIA

We now come to the third stage of this enquiry and prepare to examine particular instances in which we find something entering into the course of Evolution which cannot be ascribed to chance variation, but is evidently the result of foresight and design. Strictly speaking, one example ought to be enough to refute the logic of those who say that everything comes by chance, but it would be very far from a satisfactory argument were we to limit ourselves to one. For by many instances a cumulative effect is produced on the mind; the argument being necessarily brought forward over and over again in somewhat varying forms becomes more familiar and better understood, and the reasonable expectations are satisfied of those who think that in the boundless wealth of natural forms many instances ought to be found of anything which enters into the making of the world. Countless examples may, indeed, be found. It would be idle pretence if anyone should boast that he had noticed them all. We can only profess here to direct attention to some of the most obvious and striking.

It would be strange, indeed, if we did not find what we are seeking amongst the many wonderful contrivances and plans which are used in the fertilisation of flowers. So much depends on this operation that all the resources of plant life seem to be drawn upon to bring about what is necessary for the welfare of each particular kind of plant. And amongst these contrivances perhaps the most striking are those which are intended to ensure cross-fertilisation, that is to make it certain that in some cases, or in all cases, the flower shall be fertilised by pollen which comes from another plant. That a plant may go on for a long time without cross-fertilisation is certain, but Darwin thought, and most naturalists think, that no plant can go on without it for ever, and all are agreed that where it occurs it gives the plant which is so adjusted as to bring it about a great advantage in the struggle for life. And from every point of view this gives us a good reason why so much complicated mechanism should be used to secure it.

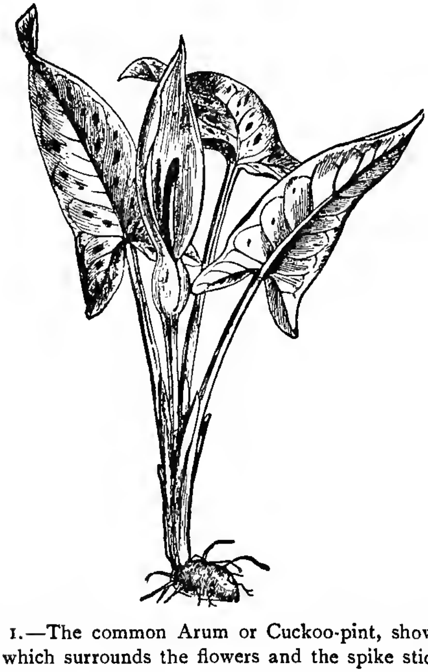

FIG. 1.—The common Arum or Cuckoo-pint, showing the spathe which surrounds the flowers and the spike sticking up in the middle.

From *Plant Life*, by Grant Allen.
By permission of Messrs. Hodder and Stoughton.

In bringing about cross-fertilisation insects are often used as the carriers to bring the pollen from one flower to another, and of this use of insects and the mechanism by which the plant profits by it we have a very good example in the common arum, known to children as cuckoo-pint or lords and ladies (Fig. 1). In describing this flower I am glad to be able to make use of an interesting little book[1] in which many curious plant structures are described in a simple way, and which will warn me not to overstate my case, as it takes it as established that everything described is the result of chance variation and natural selection.

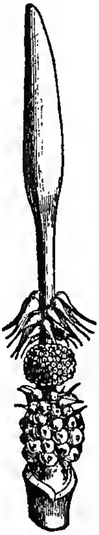

FIG. 2.—Spike of the Cuckoo-pint with the spathe cut away. Below are the female flowers, above them the male, and on the top of all, the abortive flowers reduced to hairs which form the trap.

From *Plant Life*, by Grant Allen.
By permission of Messrs. Hodder and Stoughton.

If the cuckoo-pint is carefully examined the flower, or rather what looks like the flower, will be found to be very curiously and wonderfully contrived. For it is not a real corolla although it looks like one, but an outer leaf or

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[1] *Plant Life*. By Grant Allen.

spathe which surrounds and shelters the real flowers, and is itself a part of the signal by which the plant attracts insects, just such a signal, in fact, as the corolla or coloured leaves of other flowers. Inside this spathe stands straight up a spike or club of a bright purple colour which forms the other part of the signal which attracts insects. If the spathe is cut away and this club or spike is left it will be seen to bear on the stalk which supports it the true flowers of the plant, arranged in three little masses (Fig. 2). First below in one cluster there are the female flowers, which are entirely without calyx or corolla and consist only of a single ovary for each flower. Then just above them come the male flowers, each consisting of a single stamen, also without calyx or corolla, and then higher up another group of abortive flowers of which nothing remains of each flower but a single hair pointing downwards.

Now when the cuckoo-pint exhibits its signal or flag to show that it is ready for its guest the sight affects the instincts of the little insects which frequent it and attracts them often in considerable numbers. They find it easy enough to get in but quite impossible to get out again. For just opposite to the little ring of abortive flowers the spathe is so narrowed that one of these midges has just room enough to pass down by pushing aside the little hairs, which yield easily to let it in, but on account of the direction in which they point will not give way to let it out. The midges, or some of them, have come from other cuckoo-pints and are dusted over with pollen, some of which falls on the female flowers as they crawl over them. The female flowers are ripe and ready to be fertilised, and so when the pollen falls on them the seed is formed. But the male flowers are not ripe yet and so for a little while the midges are shut up in a bare and empty prison where they certainly would not stay if the hairs at the entrance did not keep them in. They have not, however, long to wait, for when the female flowers have been fertilised the male flowers above them ripen and shower down on the midges an abundant supply of pollen on which they make a feast. Then the hairs wither and the midges are set at liberty, and so, covered all over with pollen, they fly away to another plant, where they fertilise the female flowers and are rewarded by another feast of pollen.

The present condition and shape of the cuckoo-pint must be supposed to be evolved out of a former state which did not make provision for cross-pollination by the aid of insects. The total change in the plant by which its present arrangements for that end come about involves these particular changes: (1) The flowers are divided into male and female and arranged in separate groups. (2) A certain number of flowers become abortive and are changed into little threads or hairs, all pointing outwards and downwards, and arranged in groups of their own above the other flowers. (3) The spathe closes in so evenly opposite these hairs as to afford no room for the escape of an insect. (4) The size and stiffness of the hairs are so adjusted to the size and strength of the insects as to let them in with ease but to imprison them when they have once passed in. (5) The times at which the flowers ripen are so adjusted (*a*) that the insects on their arrival find the female flowers ready to receive pollen but the male flowers not ready to give it out; (*b*) that as soon as the female flowers are fertilised the male flowers give out their pollen, not yielding it soon enough to interfere with what the insects bring nor keeping it back so long as to starve them. (6) The hairs which form the trap fall away and leave the passage open just in time to let the insects fly away after their feast covered with fresh pollen for another plant. Now all these separate arrangements must be made before the plan of the cuckoo-pint will work. It could not afford to dispense with any one of them. If the hairs, for instance, did not point in the right direction and were not of the right length and stiffness they would not make a trap. Hairs pointing upwards would keep everything out, hairs too long and stiff would be too difficult to pass, and hairs too short or too weak would be no obstacle at all. Then, if the hairs fell off too soon the midges would get away without any pollen, while if they remained too long the pollen would be eaten up or would get stale. Going over the whole arrangement in this way, it will be seen that everything must be adjusted to work true within certain limits ; for example, the contrivances on the plant must have regard to the size, strength and endurance of the insects so as not to overtax their powers in any way. Thus considered, it will be at once seen that these things could not have come about by chance. No such arrangements or adjustments could have been contained in any previous state in which it was not fertilised by insects. Even if some parts of the contrivance were there the adjustment of each to each could not have been there, and it is in the adjustment that the contrivance consists.

Moreover, the parts and their adjustments must all be there together before the machine will work. Now even the most ardent Darwinist will hardly think that the whole of this contrivance could spring into existence by a happy chance at a single moment. (Darwin always spoke of the accumulation of slight variations.) Then part of it would have to come and wait until another chance brought the rest. But what is to keep it there while it waits ? Natural selection cannot act on anything that is not working and whatever is not preserved by Natural Selection has a tendency to dissipate and to be lost, so that one part of the machine, if it were such a part as might come by chance, might come and go and never meet the rest.

Now Mr. Grant Allen thinks that he can see how the evolution of the cuckoo-pint comes about, and this is how he describes it :

" In this case it is an interesting fact that all the stages which led to the existing arrangement of the flowers still remain visible in other plants for us. These very reduced little blossoms of the cuckoo-pint, consisting each of a single carpel or a single stamen, are yet the descendants of perfect blossoms which had once a regular calyx and corolla. Near relations of the cuckoo-pint live in Europe or Africa to this day, which recapitulate for us the various stages of its slow evolution. Some, the oldest in type, have a calyx and corolla green and inconspicuous, with six stamens inside them enclosing a two or three celled ovary. These are still essentially lilies in structure. But they have the flowers clustered, as in a cuckoo-pint, on a thick club-stem, and they have an open spathe which more or less protects them. Our English sweet-sedge is still at this stage of evolution. The marsh-calla of Northern Europe and Canada, on the other hand, has a handsome white spathe to attract insects, while its separate flowers still both male and female together have each six stamens and a single ovary. But they have lost their perianth. The common white arum or ‘ calla-lily ’ of cottage gardens has a bright yellow spike in its midst, and if you look at it closely you will see that this spike consists entirely of a great cluster of stamens thickly massed together. The top of the spike is entirely composed of such golden stamens, but lower down you will find ovaries embedded here and there among them, each ovary, as a rule, surrounded by five or six stamens. Lastly, in the cuckoo-pint the lower flowers have lost their complement of stamens altogether, while the upper ones have similarly lost their ovaries ; moreover, a few of the topmost have been converted into the curious lobster-pot hairs which assist, as I have shown you, in the work of fertilisation. We have here a singular and instructive example of what may be described as *retrograde development.*"

Now how does all this help us to account for the plan of the cuckoo-pint ? It is like accounting for the plan of St. Paul's by showing us bricks and stones, pillars and arches in other buildings. Here we have some of the materials used in the plan, but here most certainly we have not the plan. We are enquiring for the architect's studio and we are shown into a brick-maker's yard. Certainly if all these plants are evolving in the line of the cuckoo-pint, if they are preparing for a future condition in which they will be cross-fertilised by insects, they are under the guidance of some intelligent being who foresees what is coming and is preparing for it. In no other way could we account for the appearance and preservation of features which are of no use at present but which may be of use at some future time. But they may not be progressing in this direction. They may be only turning up all the possibilities of their present design without any tendency to leave it, and thus showing some of those features which in the case of the cuckoo-pint were made use of by superintending intelligence as the basis of a new plan. If this is so they, too, may have similar possibilities in store for them, but not by mere chance. However long chance variation may go on it can never produce anything new, it can only bring out all that is in the old. If we persevere in throwing the dice we shall get in time all possible combinations, but we shall get nothing more. We are certain of sixes, but we need not hope for sevens. The sixes and other common throws in this care are the various changes of which the flower was originally capable without altering its plan, the sevens are the arrangements for capturing the carrier insects.

The Aristolochia (Fig. 3) is another plant which makes use of the services of insects to secure cross-fertilisation in much the same way as the cuckoo-pint. In the figure which gives a section of the flower of *Aristolochia clematitis* we see how the contrivance works. Aristolochia differs from cuckoo-pint in having a perianth, so that what we see is part of the real flower. The perianth has a wide, open mouth (Fig. 3, A) to which the insects fly and a narrow tube down which they can crawl. The internal surface of this tube is covered with hairs which point inwards and downwards, so that insects can readily enter but cannot escape. As they creep about the chamber in which they are im-

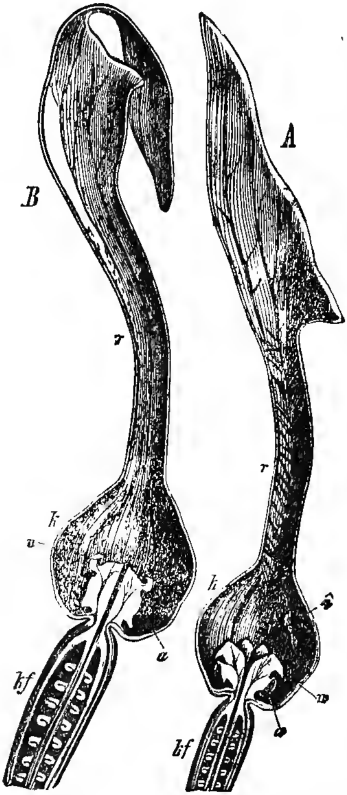

FIG. 3.—SECTION OF FLOWER OF ARISTOLOCHIA.

A Flower with perianth open. B Flower closed by fall of top of perianth. *r* the tube of the perianth lined with hairs. *k* the cavity below. *w* stigma. *a* anthers. *kf* ovary.

From Professor Vines' *Student's Text-book of Botany*.
By kind permission of Messrs. George Allen & Co.

prisoned they come into contact with the anthers which may be seen in its lower part, and as some or all of them have come in dusted over with pollen from another plant fertilisation is thus accomplished. As soon as this happens the stamens give out their pollen, the hairs in the tube wither and fall off, and the insects thus set free and well covered with pollen fly off to another plant where they do the same thing over again. The top of the perianth then falls down so that the tube is closed and no more insects can get in. The second drawing (B) in the figure shows the flower in this state.

Here we have, as before, a flower which displays a new plan, a new kind of order or arrangement, and which, in consequence, gives us a manifest example of design. The arrangement cannot have been made by chance or by any kind of blind, unforeseeing impulse, but by a conscious intelligence looking forward to the visits of insects and planning how to make use of them. It will be noticed that while the design is the same it is not carried out in precisely the same way. The trap is not composed of abortive flowers but of hairs growing in the upper part of the flower, and there is no central spike or club. But for all that it is really the same design that we have before us in both cases.

It is for this reason that I have brought it forward. I have imagined that there might be some reader who had so often said to himself that chance might produce a working machine that the habit would reassert itself and, notwithstanding all that has been said, he would still go on saying it and I want to ask him whether he would expect chance to produce the same machine twice over. Here are two plants very different from one another. They are not closely related, since one is a monocotyledon and the other is a dicotyledon, and therefore the arrangement and use of the parts which we are considering must in each plant be quite independent of anything in the other. This is not anything that might have come from a common ancestor. It must have sprung up independently in each case. Now, over and above the difficulty or, rather, impossibility of ascribing a new plan to the accumulation of chance variations, surely we have another impossibility here. The same thing has happened twice over. How can anyone imagine that the mere coincidence of chance variations having once produced this complicated contrivance should then set to work to produce it over again? Here are the plain marks of consciousness and foresight. The insects are deliberately provided for.

Or if the reader has been accustomed to tell himself that the course of evolution is to be accounted for by an unconscious force or impulse which he calls Life, Nature or the Order of the Universe, or by any other name, I would ask him to consider whether these abstractions, even when honoured by capital letters, give him any explanation whatever of the change which has occurred. Whatever force or impulse acts upon an organism is acting with or without a view to the future. If it has regard to the future what is it but conscious intelligence, and if it has no regard to the future what is it but chance? To say that a force acts from within and not from without makes no difference. The only question is whether it is conscious of the future and provides for it, or whether it knows nothing of the future and pushes blindly on. We know of nothing that can act with regard to the future except conscious intelligence. As the future does not yet exist it can only be considered in thought. And, therefore, apart from intelligence and design there can be no explanation of future-regarding changes. This is what I would like such a reader to consider in the face of such examples of organisation evolved and working as the cuckoo-pint and the Aristolochia, and if he will not accept the explanation here offered let him at least acknowledge that there is no other. In anything else that is proposed as an explanation we are given nothing but empty words.

CHAPTER XV

THE FERTILISATION OF ORCHIDS

In the mechanism which brings about the fertilisation of orchids by insects we have a series of arrangements and plans showing every possible mark of foresight and design. These plans differ from those which we have just considered in being much more elaborate and complicated. They make, therefore, a much deeper impression on the mind and are well worthy of a thoughtful and careful consideration. In fact there is hardly anything in the whole range of plant life that strikes the observer as more wonderful and admirable than the design and construction of an orchid. And when we remember that this flower was undoubtedly evolved from some other form which was not fertilised by insects, and which discharged all the functions of a flower without any reference to them, we see that we are in the presence of a new plan, a new arrangement of parts not in any way contained in or arising out of any former plan or arrangement. The flower began at some time as a new thing to make use of insects. And no new thing could ever arise without the guidance of some intelligent being able to look forward and arrange what is with a view to what is to come. As for supposing that a flower which was in working order, according to one plan, could change its shape and the use of many of its parts and get into working order according to another plan, without intelligent guidance, we might as well suppose that a fleet which was drawn up in one formation, say in one long line, could steam ahead into another place and get into another formation, say three parallel lines, although each of its ships were committed to the sole guidance of a blind steersman.

Darwin has written a most interesting book[1] on the Fertilisation of Orchids. It is next to his great work the best of all his books. I would dearly like to annex that book for the purpose of this argument and display it to the reader as conquered territory yielding a noble tribute for our support. It would be all the better to make such a conquest that its whole atmosphere is so congenial that nothing more pleasant could be desired. From beginning to end the language used is such as to imply and to keep before the mind the conception of design and foresight. I would be the last in the world to try to take any unfair advantage in controversy of the use of such language. Darwin would probably have said that he used it for convenience and to avoid intolerable circumlocutions, but that he expected the reader to understand his real meaning without any difficulty. I would accept the explanation. I fully understand his meaning, I allow his way of speaking as legitimate, and I do not make it out to be an involuntary admission of error. But yet, after having by other and invincible arguments shown that the plans described in the work are the result of design and must be so understood, I confess that it is a satisfaction, and I believe no undue or improper satisfaction, to be able to say that no new or corrected edition is wanted ; but that except for a word here and there what Darwin wrote will express the true view of the matter as easily as any other.

The best way of approaching the subject seems to be to follow Darwin in describing the structure of *Orchis mascula*, the first to be treated of in his book, explaining how it gives support to the argument maintained in these pages and to leave the reader, if he pursues the subject farther, to consider the other orchids mentioned in the light of this exposition. We need not dispute Darwin's judgment in selecting *Orchis mascula* as the most suitable beginning for those who are considering the matter for the first time.

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[1] *The various Contrivances by which Orchids are fertilised by Insects.* By Charles Darwin.

The fertilisation of this orchid is effected thus. When a bee or other insect of suitable size comes to feed at the flower's nectary it carries off, on leaving, a club-shaped mass of pollen firmly glued to its head. When it arrives at another flower this mass of pollen has so changed its position that it points directly at the stigma and strikes against it as soon as the insect begins to feed. The flower is elaborately shaped and prepared to make use of the insect in this way. There is first of all the landing-place on which the insect rests, which is so contrived as to put it into the right position for abstracting the pollen from one flower and conveying it to another. Then there is the mass of pollen ready to be carried off with its stalk of proper length and its foot carrying a drop of glue so placed that the insect cannot fail to touch it. Then the glue is of the proper consistency and sets hard with sufficient speed, the stalk bends down so as to get the pollen into the right position, the stigma is found to be so sticky as to take off a sufficient quantity of pollen and yet not so sticky that it does not leave some for another flower, and the pollen itself is divided into parcels so that it does not all go at once. Here are at least ten different adjustments, all combining to one end and of which no one implies or is the cause of another, and when we enter into details we shall see that each of these is really the result of a more or less complicated process, so that in fact the adjustments are many times ten. Any nine of these would be useless if the tenth were absent, and not one would be of any use if the flower were fertilised otherwise than by the agency of insects. Can we believe that all these adjustments arrived by chance, without any foresight or intention? Can we suppose that without any thought of an insect in any mind but just by accident, spontaneously all these adjustments started up together and got to work,

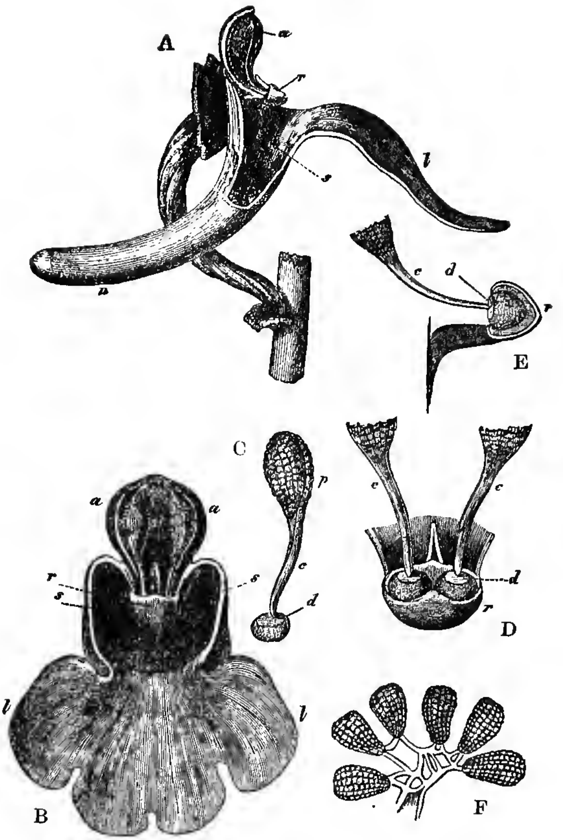

Fig. 4.—Orchis Mascula.

A Side view of flower with all the petals and sepals cut away except the labellum, of which the near half is cut away as well as the upper portion of the near side of the nectary. B Front view of flower with all the petals and sepals removed except the labellum. C One pollinium showing the pockets of pollen grains, the caudicles and viscid disc. D Front view of the caudicles of both pollinia with the discs lying within the rostellum, its lips being depressed. E Section through one side of the rostellum with the included disc and caudicle lip not depressed. F Pockets of pollen grains tied by elastic threads here extended. *a* Anther consisting of two cells. *r* Rostellum. *s* Stigma. *l* Labellum. *p* Pollen mass. *c* Caudicle of pollinium. *d* Viscid disc.

From Darwin's *Fertilisation of Orchids*.
By kind permission of Sir Francis Darwin.

or that they came one by one, and the first comers, without reason, thought or foreknowledge, waited for the arrival of the others? Surely so monstrous a demand need only be made to be rejected, and yet this is what we are asked to believe by those who try to get rid of design and thought as explaining the course of evolution.

When an insect comes to feed on the honey stored in the nectary of *Orchis mascula* it finds a broad leaf standing out invitingly as a landing place just at the opening of the nectary. This leaf, which botanists call the labellum, is one of the three petals which the flower possesses, but it is that which must originally have been the upper petal. That it might take the part assigned to it in the new mechanism the whole flower has been twisted, so that what was once the top has become the bottom, and the marks of twisting are still seen in its support.

Now, whether we suppose that the flower twisted suddenly in the growth of one generation just so far round as was necessary, and no more, or that it moved gradually round in the course of many generations, we shall be equally at a loss to conceive how this change could come without any intelligent guidance to regulate the degree of twist. If we suppose it to have come about slowly we must also suppose that a way was found of carrying on the functions of the flower while the change was in progress.

If we suppose that a bee has alighted on the labellum it will be seen from Fig. 4, A that she will have before her the opening of the nectary, which is so narrow that she must stand straight before it when she puts her proboscis in to extract its contents. The nectary is also so long that the bee in getting at its far end will come forward and touch the rostellum which is placed immediately over the opening. No sooner has this happened than one pollinium at least is fixed on the insect's head and she is ready to fly away and fertilise another flower. We must now see what it is that she has fixed on her head and how it came to be there.

Standing up in front of the bee as she sucks the honey out of the flower is a structure which is called the column. This is composed of the one stamen and three pistils which the orchis possesses. The one stamen supplies two anthers, each containing a mass of pollen shaped like a club ; two of the pistils form the two stigmas or female organs, which appear one at each side just over the opening of the nectary, while the third pistil is modified, and instead of a stigma produces the rostellum, which is the contrivance for fastening the mass of pollen on the bee's head.

Now every part of this column shows some wonderful and complex adaptation by which it is fitted to take its part in the work of fertilising some flower. And first, the anthers contain each a mass of pollen resting in its cell, where it is held ready to be carried away at the proper time. Before the flower has opened, the anther or cell has split down the front so that there is nothing to keep back the mass of pollen when the bee lifts it out. This mass of pollen is so constructed that there may be no waste. If it were all one mass when it touched the sticky surface of a stigma it would all stay there and it would only be able to fertilise that one stigma. But instead of being all one it is composed of several masses of pollen held together by elastic threads. These threads are not too strong and, therefore, when a stigma is touched one mass of pollen is retained, its thread breaks and the bee flies away with the rest to deposit it on some other flower. The masses of pollen may be seen spread out at Fig. 4, F, showing the threads which hold them together.

The elastic threads which tie the pollen masses together unite to form the caudicle or stalk by which they are fastened to the rostellum. When the bee carries off the pollinium this caudicle bends down and holds the mass of pollen a little forward, so that on entering a flower it will be sure to touch the stigma. The mass of pollen with the stalk or caudicle and the little disc at the end by which it is glued to the bee's head taken all together form the pollinium. The pollinium is just what the bee carries off.

A wonderful thing about the pollinium is that it is made out of two parts of the flower and these two parts so different as a stamen and a pistil. The stamen produces the upper part, the pollen and the threads that make the head and caudicle, and the pistil produces the lower part, the disc and the drop of adhesive matter. The pistil also supplies the pouch or pocket in which the drop of glue is kept moist and ready for use. The part supplied by the pistil is called the rostellum. It is at first a roundish bag which adheres to the column and to the top of which the caudicles of the two pollen masses become attached. Then, as the flower becomes ready for opening, the contents of this bag are formed into two drops of a sticky substance like glue, adhering to the inside of the covering just under the foot of each caudicle, with a liquid which surrounds the glue and keeps it moist and sticky. Then a crack comes in the covering of the rostellum which either actually separates or is ready to separate at the slightest touch, and this crack cuts out two oval discs, one at the end of each pollinium, which are now only fastened to the caudicle and which carry each its drop of glue beneath. The rest of the rostellum remains attached to the column as a pouch or pocket in which the two pollinia stand side by side waiting for the bee.

This arrangement may be understood by referring to Fig. 4, where at C one pollinium may be seen with the mass of pollen above, the stalk or caudicle next, and the disc and drop of glue below; the first two being the parts it has from the stamen, the last two what it gets from the pistil. Then at D may be seen a front view of the rostellum, but the edge of the pocket is pushed down a little to show the discs and drops of glue behind. At E may be seen in section the rostellum, holding the lower part of the pollinium as it actually does and covering up the drop of glue to keep it from the air.

We now know what the bee finds ready for her when she alights on the labellum. Before her is the nectary containing the sweet juice for which she has come, above the opening of the nectary stand the two pollinia with their heads of pollen shielded by the two anthers and their sticky feet standing in the pocket of the rostellum. They are all ready to act and are only waiting for a touch.

The pocket of the rostellum is very easily pushed away from the foot of the pollinium, the merest touch will do it. But although so easily moved it is very elastic, and when the pressure is taken off it springs up again, so that if the bee only carries away one pollinium the foot of the other is kept from the air and preserved in a moist and sticky condition waiting for another chance. When the head of the bee pushes away the pocket of the rostellum it touches the drop of glue at the foot of the pollinium, which is thus firmly fastened on. The readiness with which the pollinium comes off may be seen by introducing a sharply pointed pencil into the opening of the nectary. When it is withdrawn it will be found to have one or both pollinia adhering to it. A pencil carrying one pollinium is shown at A, Fig. 5.

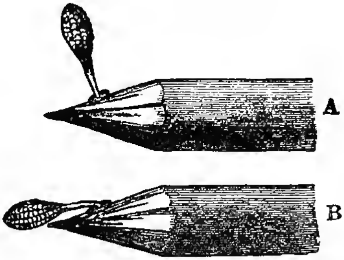

FIG. 5.—ORCHIS MASCULA.

A Pollinium just attached. B Pollinium after depression.

From Darwin's *Fertilisation of Orchids.*
By kind permission of Sir Francis Darwin.

The glue or sticky substance on the foot of the pollinium is of such a nature that it sets hard and firm immediately on exposure to the air. So that when it has once taken hold it is in no danger of being shaken off.

But all the contrivances which have been described would be absolutely useless if there were not yet one more. For it will be noticed that if the bee carried the pollinium to another flower just as it receives it, it would never get near the stigma at all. If the pencil bearing the pollinium is immediately put back again it will carry the pollinium into the place where it found it, that is, into the anther, and the pollen will be no nearer the stigma than it was before. But the pollinium does not remain in the same position. In about half a minute, just the time that it will take the bee to fly to another flower, that part of the little disc which was next the column and which is in front as the bee flies forward contracts so much that it pulls down the caudicle and makes it turn through a right angle. The pollinium on the pencil is shown at B, Fig. 5, as it appears when bent down at the end of half a minute. Then, when the bee alights on the labellum of another flower, the pollinium points forwards and it strikes against the stigma as soon as the bee has got its proboscis into the nectary. The stigma then has to do its part. The pollen of the orchis is not loose and powdery, as pollen so generally is, but firm and compact. But the surface of the stigma is sticky and thus the pollen adheres to it. Yet it is not so sticky as to keep all the pollen, but some is sure to be left for the next plant visited by the bee.

Now in all this complicated arrangement everything fits into everything else as a key fits into the wards of a lock. There is a complete plan or design which would utterly fail if any part were wanting. In fact, if any one part were not there the design would not be there. And this design cannot possibly be represented as a mere variation of some former plan which provided for the fertilisation of the flower otherwise than by the aid of insects. It all points to the insect, prepares for it and will not work without it. Whenever and however it arose it must have been guided by some intelligence which knew all about the insect and used it deliberately. The whole thing gives us a decided negation of blind chance.

If the reader cares to pursue the matter farther he will find in Darwin's book that the different species within one tribe show variations in details which may very reasonably be taken to be chance variations fixed by Natural Selection. But in the different tribes he will find differences of design which can by no means be supposed to have arisen out of these variations in detail. For chance variations, when built up and accumulated, only give the various forms of the same plan, they do not pass into a new one. The plan of one kind of Orchid can no more be treated as the chance variation of the plan of another, than the results of spinning a teetotum bearing ten numbers can be treated as the chance variation of the results of throwing a die which bears six. Thus every tribe amongst the Orchids gives us its own instance of design and adds its own special contribution to the weight of our cumulative argument. Let each instance be regarded in the light of the discussion contained in our first and second part, and an increasing clearness of conviction will result.

CHAPTER XVI

THE EYE

THE higher orders of mammals have now very complicated and highly efficient eyes. If we trace their ancestry backwards according to the Evolutionary theory we come at last to very primitive and simple forms which exhibit no organ at all resembling an eye, and show no signs of the possession of any power of sight. We must suppose, then, that at some point in the line of descent the faculty of seeing began to appear, that its organs passed through a course of evolution and that finally, after many ages, their present perfection was attained. And we say that the first appearance and subsequent evolution of these organs must have been guided and controlled by an intelligence which knew how to make a present arrangement of things with a view to the future. It will confirm this assertion if the construction and working of the eye is described with some detail. It has been already shown that no new arrangement, no fresh design could come in by chance. Such arguments are necessary and convincing. But they do not affect the mind with such overwhelming power as does the contemplation of a particular instance when an elaborate and beautiful design is considered in detail and all its parts are seen in their mutual workings and correspondences. Then a belief arises which cannot be repressed, that this thing happened by no chance variation but that it was produced intelligently and of set purpose. It is the elementary thought which is the first product of our intelligence brought out into the light of day by contact with the workings of Nature. The veteran naturalist, Alfred Russel Wallace, tells us that Darwin used to say that it gave him a cold shiver to think of the structure of the eye. What he experienced was this natural and fundamental belief coming into collision with his theory of Chance Variation and Natural Selection. Being very naturally dazzled by the brilliancy of his discovery he had come to think that it must necessarily account for everything, and yet he could not feel that it would account for this. It is no wonder, then, that he should feel uneasy when he thought of the eye. It was a feeling such as many would conceal. But Darwin was a thoroughly honest naturalist and would never think of concealing a difficulty. He knew that difficulties are often the keys to new truths. And he was too great in himself to be jealous of others and to keep back the key lest it should open a door into which he had never entered. His difficulty may be made the key to a fresh truth now. He was a true discoverer, but his discovery has its limits. Chance Variation does not account for the whole course of evolution. There is also a place and a necessity for design. And we never feel that necessity more strongly than when we contemplate the functions of such an organ as the eye, and more especially when we take as our example the human eye.

The eye is made up of two distinct parts which in the process of embryonic development are found to have different origins. The one is an organ of vision which grows from the brain, the other an optical instrument which grows from the epidermis and cutaneous tissues. By the union of these two this wonderful and complicated organ is formed. The optical instrument forms an image of the object looked at, and by means of this image the organ of vision enables us to see it. We shall first consider formation of this image and see what contrivances are used to bring it about.

Every object is seen by means of the rays of light that it gives out. If, like a dark hole, it takes in all the light that falls on it sending out none there is nothing to see. If it is so smooth and polished that it takes nothing but reflects everything as a clear mirror does, then it does not give out the light, it merely interposes as an obstacle and changes its course, and the light shows us not the mirror that reflects it but the objects that really give it out. But when the light gets into the surface and then comes back again, having been altered by contact with the object in its colour or intensity, then the object gives out the light and we see it. Now if any other object gives out the same quality of light arranged in the same way, that second object is a likeness or representation of the first. Thus a picture shows us what an object is like because it gives out light in the same way as the object does, and yet we will not mistake it for the object because the light that it gives out is not precisely the same as what comes from the object itself. Suppose, then, that we want to get an accurate image by using the rays of light which actually come from the object itself. How shall we get them to come together so as to make the image where it is wanted?

If in a board C D, Fig. 6, we make a hole it is evident that light from all parts of the object A B will pass through and, if the board is the front of a box, will fall on the back of it at *a b*. We know that the light comes in because by looking out through the hole we see the object. But it will make no image, for the light from each point of the object will enter through every part of the hole and spread itself out over a space at the back, *a b*, the same shape as the hole but larger, every point in which will receive light from many parts of the object, and in the case represented by the figure, one point, I, will receive rays from every part of it. If we were to look out from any part we should see a considerable portion of the object through the hole. Thus at any spot we shall have a mixture of rays of light from many parts of the object, but nothing that could make an image.

But if the hole is made very small, say the size of a pin-hole, each point will receive light only from a small part of the object, and so a distinct image will be formed. But, as very little light will be let in, the image thus formed will be very faint and dim. Such images have, however, been used for making photographs of motionless objects with very good results.

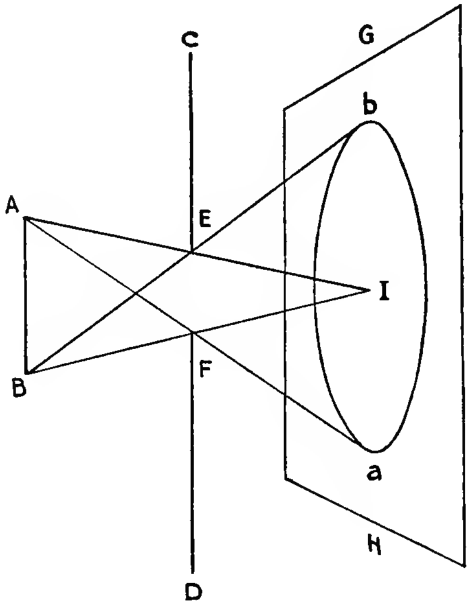

FIG. 6.—The scattering of rays of light.

But if we now introduce behind the hole a lens of suitable power as at E F, Fig. 7, everything is changed. For the lens has the property of causing the rays of light which come from one point in the object to meet together in another point a certain distance behind it, and if the screen or the back of the box is just at that distance a clear image of the point will be formed there. Thus the rays from A are all collected at *a* and the rays from B at *b*, and are found nowhere else, and in like manner the rays from each point between are found at one point only on the screen. If then the screen is covered with something like white paper, which allows the character of the light which falls on it to be distinguished, each part of the image will give out rays of the same sort as are given out by the corresponding part of the object itself. The rays, however, cross in passing through the hole, so that the image is upside down. This is the sort of image which a photographer gets in his camera and this is the sort of image which is formed in the eye.

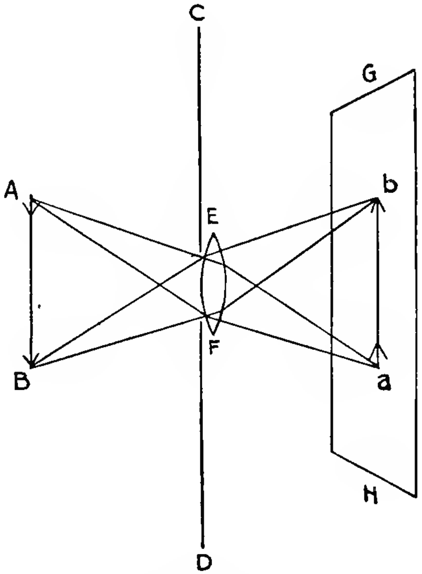

FIG. 7.—The collecting of rays to form an image.

We must now consider two difficulties which are met with when we try to make such an image and explain how they are overcome. In considering them we may also get a clearer notion of the part the lens plays in making the image.

When a ray of light passes from one transparent medium into another it is usually bent out of its course. If it passes from a thinner medium into a denser its path lies closer to the perpendicular which may be drawn to the surface of the medium than the course which it would have pursued if not interrupted, if it passes from a denser to a thinner medium it bends away from the perpendicular. Fig. 8 represents a ray of light passing out of the air into a glass prism, which is shown in section, and into the air again. At the point where it enters the glass and the point where it leaves it perpendiculars have been drawn to show how its course is affected. Passing from the thinner medium, that is the air, into glass which is much denser, instead of going on straight as shown by the dotted line, the light bends towards the perpendicular. When it leaves the glass again it bends from the perpendicular, but on account of the way in which the two sides of the prism slope together it comes out as it were at the other side of the perpendicular, so that when it first bends towards and then from the perpendicular it bends each time in the same direction. The result of its bending twice is that it is turned a good deal out of its course. This enables us to understand how a lens acts. At every point it is sloped like the side of the prism, but the slope is always changing as we pass out from the centre to the edge of the lens, getting continually greater and greater, so that the rays of light which fall farthest out meet with a greater slope than those which are nearest

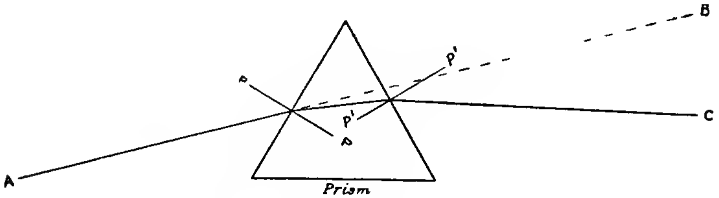

FIG. 8.—A ray refracted by a prism.

the middle and are more bent than they. And this slope is so nicely graduated that they are all bent in proportion to the distance they have to go in order to meet in one point. Thus the prism explains to us how the lens brings light to a focus and forms an image.

But, strictly speaking, all this is only true if we are dealing with light of one colour. A beam of red light or a beam of violet light would behave exactly as has been described. But if a beam of sunlight, which contains seven colours, is passed through the prism it is immediately evident that the colours are differently affected, some being more bent and others less, but no two exactly the same, so that instead of falling on one spot and showing white the ray of light is spread out into a line and shows seven distinct colours. This is represented in Fig. 9, where the seven colours are shown in their order: Red, Orange, Yellow, Green, Blue, Indigo, Violet, the red suffering the least refraction, that is, being the least bent, and the violet suffering the greatest refraction, that is, being the most bent of all. This is what is meant by dispersion. The effect is, of course, exaggerated in the figure in order that it may be shown in a small space, but if a piece of glass of the shape given in the illustration is held in the sunshine it will be immediately observed, or by looking through the prism all the objects seen will be found to show fringes of many colours.

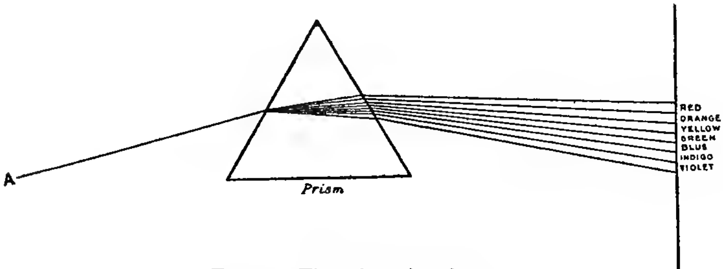

FIG. 9.—The prismatic colours.

Now a lens bends the rays of light just as a prism does and, therefore, it also disperses them like a prism and, for a long time after the invention of the telescope, it suffered from this defect. Even now we sometimes come across very old telescopes or very cheap ones which show coloured fringes round everything. But nobody could find out any remedy until the thought occurred to a man of genius named Euler that as we do not see things with coloured fringes there must be something in the eye to correct dispersion and that telescopes might be improved by imitating Nature. Possibly some modern Naturalist who maintains that there are no designs in Nature would have suggested that the way to imitate Nature was to go on making telescopes in the customary style and constantly to be on the watch for something to turn up. Fortunately Euler did not take this course, as telescopes were made then with a simple lens and the correction is given by a double one. Even the modern Naturalist would hardly expect a double lens to occur as a chance variation in the course of manufacturing single lenses. But Euler looked for a design in the eye and he found one by which it has ever since been possible to apply a complete correction to the dispersive tendency of any lens.

The correction is founded on two facts. First, that the refractive and dispersive powers of different transparent substances vary considerably and, secondly, that the power which a substance has of dispersing the colours is not at all in proportion to its power of bending or refracting the light. It is possible, in fact, to find one kind of glass which has great power of refraction and but little power of dispersion, and another kind which has great power of dispersion with only a slight power of refraction, and by combining these two the correction is made. In Fig. 10 A, B, C represents a double convex lens, which is to be made of glass, which has great power of refraction but as little power of dispersion as possible. To this is applied on the right a lens A, D, C, E, concave on one side but flat on the other. The flat side affects the state of things no more than one side of a window pane, but the concave side contradicts what the convex lens does. If the convex lens makes things look bigger the concave makes them look smaller; if the convex bends a ray of light one way the concave bends it the other way; if the convex separates the colours the concave gathers them together again. This lens, therefore, is made of glass which has but small refractive power, and, therefore, although it works against the other lens and bends the rays in the opposite direction it does not bend them much and thus does but little harm. But it has great dispersive power and, therefore, as it works against the other lens in this also it brings together the colours which the other had separated. The two kinds of glass may be so well matched with each other that every defect of this kind shall be corrected and the compound lens shall be perfectly achromatic, that is to say, shall not in any degree separate colours or give coloured edges to

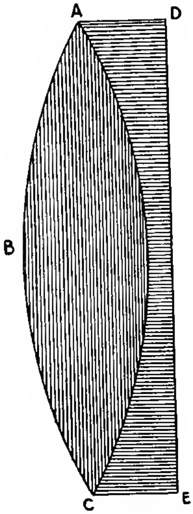

FIG. 10.—An Achromatic lens.

objects seen through it. This is the plan which was discovered by examining the structure of the eye, for the eye, as we shall afterwards see, has three lenses which differ from one another both in dispersive and refractive powers.

There is another defect in optical instruments which is even more difficult to deal with than chromatic aberration. This is spherical aberration, and is due to the shape of the lens. The rays of light, as we have seen, which issue from any one point and fall on the face of the lens are brought together again at another point on the other side. The centre ray, which strikes the glass perpendicularly, is not bent at all but goes straight on; those that fall near it are bent a little, those that fall farther off are bent more. All the rays are bent so nicely in proportion to their distance from the centre that they all meet in one point. But although this is almost true, yet with the shape of lens which is most easily made it is not quite true. The lens which can be most easily and accurately constructed is the spherical lens, the surface of which is part of a sphere. A section of this lens is bounded by lines which are parts of circles. But in such a lens the outer parts are more powerful than the centre. This is shown in Fig. 11, where the outer rays A, B, A^1 and A, E, A^1 come together much nearer to the lens than A, C, A^2 and A, D, A^2, which are closer to the centre. The effect is as usual exaggerated in the figure, but in practice it is quite great enough to be of some importance.

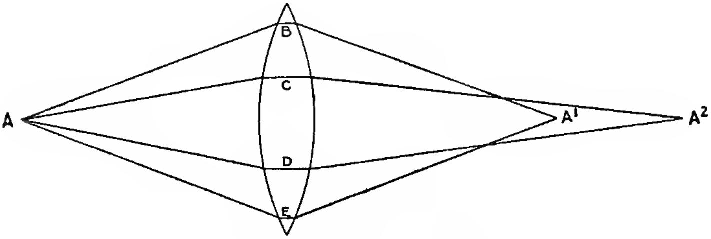

FIG. 11.—Spherical aberration.

The correction was found very difficult. It was made by using the ellipse rather than the circle as a guide in shaping the lens. And it was looked upon as quite a triumph for the optician's art when a method was found of grinding the lens accurately to the required shape.

This is one way of making the correction. But there is evidently another. For if the lens became denser as it approached the centre so as to have greater refractive power the effect would be just the same. But this would be too difficult for the optician to attempt. It appears to be impossible to graduate the density of the glass in such a way as to make the power of the lens equal all over. Yet this is just what is done in the eye. The crystalline lens has this graduated structure and becomes denser towards the centre. To anyone who ponders it carefully this fact will be very impressive. The structure of this lens involves a very elaborate arrangement of innumerable particles of matter and there is no reason why they should be thus arranged except that it is an arrangement useful for seeing. But what was to bring it about ? Not chance, for chance creates no new order, certainly not an elaborate order embracing many things. Not any unconscious power, for why should it move in this direction and so far, and not in an infinity of other possible directions ? Nothing could have brought it to pass but the action of some conscious intelligence, and the more we think of it the more clearly shall we see that this is so.

Having thus generally considered the way in which an optical image may be formed, we must now examine the structure of the eye in which such an image is formed that by means of it we may see. The eye is a sphere or globe about an inch in diameter. Its principal parts are represented in Fig. 12. It has an outer covering called the sclerotic coat. This is strong, tough and elastic, and keeps the eye in shape. It yields when pressed, but as soon as the pressure is removed recovers its form again. The muscles which move the eye are attached to it. It is the mechanical support of the whole apparatus. The sclerotic coat is of a white colour and forms what is called the white of the eye. It covers everything except one little circle in the middle of the visible part of the eye.

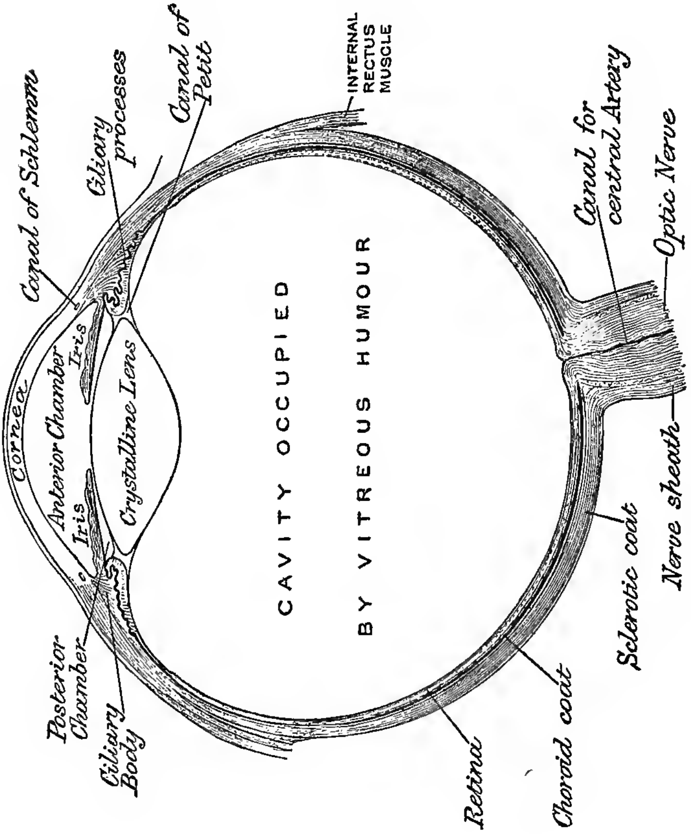

FIG. 12.—A horizontal section of the eyeball.

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This circle is covered with a membrane, thick and strong, like the sclerotic coat, but clear and transparent, because here the light comes in by which we see. It bulges out from the front of the eye, looking like a piece of a smaller globe set on a larger, because it is one of the lenses of the eye and has to assist in forming the image. It is called the cornea.

Just behind the cornea we see, when we look into the eye, a coloured band which runs right round the whole space which the cornea covers leaving a dark hole in the middle which is sometimes larger and sometimes smaller. This band is the iris and the hole in it is the pupil. Its use is to admit into the eye just so much light as is required and shut out the rest. When there is but little light the iris contracts and gets narrow, leaving a large hole in the centre, when the light is very bright the iris gets broad and leaves the pupil small. If we go from the bright sunshine into a dark room we can see nothing at first because the pupil is too small to let in enough light; we have to give it time to open. When we go out again into the sunshine it lets in too much light and we are dazzled until it has had time to close up. But the iris works so well and quickly that changes less great and sudden are hardly noticed, and we may pass through many degrees of illumination without being conscious of it.

We have noticed that the sclerotic coat forms a sphere divided into two unequal parts by the iris. The part of the sphere behind the iris contains the crystalline lens which is next it and then behind that the vitreous humour. Surrounding these there are the two linings of the sclerotic coat.

The outer lining, that is the lining next to the sclerotic coat, is called the choroid coat. It is very dark-coloured, almost black, and its use is to absorb and quench the rays of light which fall on it that the eye may be kept dark except for the image formed at every moment by the light from objects in front. The choroid coat covers the whole of the inside of the eye as far as the iris, and with the addition of some muscular fibres it forms the iris too. Just where it begins to form the iris it sends out another layer which becomes a collar or setting round the crystalline lens. This black background is very necessary to make the image clear and distinct. Photographers blacken the insides of their cameras and sometimes add a black backing to their plates for the same reason. If they did not, the light from the image would be reflected backwards and forwards and fall at various angles on the photographic plate so as to interfere with the result, which should be due only to the direct light of the image itself.

The inner lining of the eye is the retina. It is an expansion of the optic nerve which may be seen in the figure entering the eye and then spreading out on all sides. The retina is the real organ of vision. The other parts of the eye form an optical image, but the retina is what sees. What the other parts do might be done by a camera; what the retina does is the work of living tissue. The retina is extremely thin. At the most it is one-hundredth of an inch in thickness, and in some parts it is not so much. It covers the whole of the back and sides of the eye and extends as far forward as the collar or setting that surrounds the crystalline lens.

We shall have to return to the retina again, but now we must finish the description of the other parts of the interior of the eye. Within the cornea there is the aqueous humour, a watery fluid, being, indeed, very little more than water in which a little salt is dissolved. It fills the whole space between the cornea and the crystalline lens both before and behind the iris; this is marked in the figure *Anterior Chamber.* On it the light first falls and it acts as a lens—the first part of a compound lens—in bringing it to a focus.

Next to it comes the crystalline lens, which is the principal lens and does most of the work. To it falls the duty of adjusting the eye to the varying distance of the objects looked at. When the object is at a very great distance in front of the lens so that the rays that come from one point to the different parts of the lens do not appreciably differ from parallel lines the image is formed at a certain distance behind the lens. This is called its principal focus. When the object comes nearer the image moves away farther. A photographer's lens is pulled away from the plate so that the photograph may be taken where the image is most distinct. This is called getting the camera into focus. But the lens in the eye is always at the same distance from the retina, so it must be adjusted in another way. The collar or setting round the crystalline lens is full of little muscles and elastic strings. By these the lens is pulled out and made a little flatter for distant objects and is contracted and made a little rounder for nearer. Thus the image is always brought into focus, that is, it is made distinct and clear on the retina. But the photographer settles his camera with care and trouble, slowly and after trials. The eye, on the other hand, does its focussing so quickly and easily that we do not notice it, except when we try to look at something too near. When the effort is almost at the point of failure we become very acutely conscious of it.

We have seen how the eye, as an optical instrument, receives the light coming from the objects looked at, bends it by means of the lenses which it contains and forms it into images of the objects free from coloured fringes or spherical aberration, and that it is able so to accommodate itself to light coming from varying distances as to throw the image clearly and sharply on the retina at whatever distance the object may be. We have now to see how the eye is moved about so as to find the object to be looked at.

The eye rests in a socket formed by the bones of the skull, and is embedded in a cushion which keeps it firmly in its place but allows it to turn with great ease through considerable angles in every direction. It is moved upwards and downwards and to right and left by four muscles which are fastened to the sclerotic coat of the eye on the outside and stretch back to a fixed point in the socket behind. These four muscles act very easily and effectively, but in moving the eye about they are apt to make it rotate a little on its axis. As this would prove inconvenient it is corrected by two other muscles which are so constructed as to act obliquely, and which oppose one another so that the eye may be rotated in either direction as required. These may be seen in Fig. 13, where the way in which the oblique muscles act is shown. The upper one (marked *Obliquus Superior*) may there be traced from its rise through its broad or working part to the angle where it contracts to a tendon, passes through the pulley or loop, turns back on itself and is attached to the sclerotic coat of the eye. The lower one (marked *Obliquus Inferior*) may also be seen, but not quite so clearly. The whole contrivance may be taken in at a glance. It is at once simple and effective, and is evidently such an arrangement as could never have come into existence except as the result of design. This is one of those contrivances which appeal to me so forcibly, which so loudly proclaim the existence of design, that I feel there is nothing more to be done than to show them. Here is some-

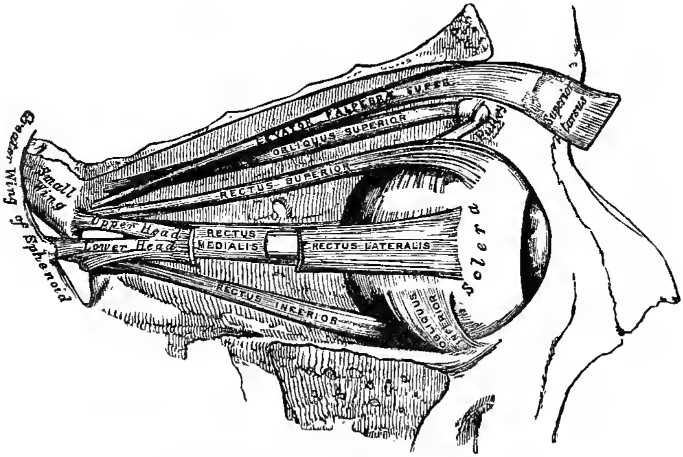

FIG. 13.—The muscles of the right orbit.

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thing that precludes the possibility of chance. Only look at it.

We now turn to the retina, the real organ of vision, without which the optical instrument which has been described would effect as little as a photographer's camera without a sensitive plate. The retina is a very thin membrane which covers the whole of the inner surface of the eye as far forward as the collar that holds the crystalline lens. It is just inside the choroid lining and outside the vitreous humour. It is the working part of the optic nerve. At its thickest part it is about one-hundredth of an inch in thickness, but towards the front where it gets near the crystalline lens it is only half as thick. One-hundredth of an inch is a very small space, but yet it is one of which we may give ourselves a fairly clear idea if we can get any small object which is exactly or almost of that size. This is, however, not very easy. Sewing-cotton, which may be had much finer than one-hundredth of an inch in thickness, is not made with such accuracy that it can be referred to as a standard. Sewing needles are more accurate. I have found that twenty-three No. 14 needles could just lie side by side in the space of a quarter of an inch. The eye would barely be able to see the difference in size between such a needle and one precisely one-hundredth of an inch in thickness. It is possible to get a rule divided into hundredths of an inch, but this is rather confusing, as the lines which separate the spaces are generally wider than what is left of the spaces themselves, so that the length indicated is made up of two parts, the width of the space and the width of the line. It is well worth while trying to realise the actual thickness of the retina, because this helps us to comprehend the amazing minuteness of its structure and organisation.

This will be seen from Fig. 14, which is a diagrammatic representation of a section of the retina. All this elaborate structure is contained in the one-hundredth of an inch. The upper part of the figure represents the outer part of the retina, which is next the choroid membrane, the lower part represents its inner side, which is next the vitreous humour. Beginning at the bottom we have first a layer of nervous threads or fibres (*a*, *b*) proceeding directly from the optic nerve which, on entering the eye, passes through the retina and spreads out in this form on its inner side. Then there is a layer of ganglionic cells (*c*) closely con-

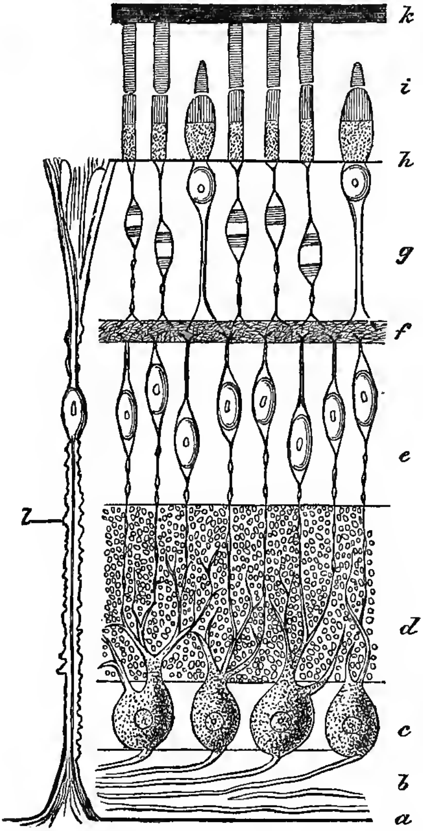

FIG. 14.—The layers of the retina (diagrammatic).

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nected with the fibres. In ganglionic cells some kind of nervous action goes on by which the working of the organ which possesses them is promoted. We can only conjecture what these ganglions are for, but reasoning from the analogy of others which are more easily examined they may be supposed to assist in the movements of the eye, the focussing of the crystalline lens and the expansion and contraction of the pupil to suit the intensity of the light. Next to this we have a granular layer (*d*) and a nuclear layer (*e*), followed by another granular (*f*) and another nuclear layer (*g*). We cannot at present say what are the functions of these layers. Next we come to the outer layer, which is in contact with the dark choroid membrane, and this is undoubtedly the part of the retina which is sensitive to light. Here the retina does its part in the actual work of seeing. It will be noticed that the light has to pass through the other parts to get at the place where seeing takes place, and the reader may, perhaps, wonder why this layer of the retina does not come on the inside so as to meet the light before the others, but he must consider that the retina is only one-hundredth of an inch in thickness, that it is quite transparent and that the working layer of the retina is by this arrangement laid directly against the dark choroid membrane, which at once absorbs the light that passes into it like the dark backing which the photographer puts behind his sensitive plate to prevent irradiation.

The inner layer, called the layer of rods and cones (*i*), responds to the vibrations of light. The figure shows that it consists of two distinct kinds of bodies which over the greater part of the eye are mixed together. The rods are about $\frac{1}{350}$ of an inch in length and $\frac{1}{14000}$ of an inch in diameter. We can get at their length very well because it is less than a third and more than a quarter of the hundredth of an inch, of which we were at the trouble to get a correct estimate. It is, in fact, almost exactly one-third of the width of a thread of No. 90 cotton, which is a very intelligible size, at least to one who has a spool of the cotton actually before his eyes. But we cannot get at their width at all. It is utterly beyond our powers of vision. By comparing threads or wires together we might hope to notice a difference in thickness between one of which one hundred thicknesses made an inch and one of which one hundred and eleven or twelve strands would lie side by side in the same space. In other words we might be able to see the one-thousandth part of an inch. But beyond this we cannot go, and the dimension of these rods is only one-fourteenth part of that little space, which is the least that we can see. In one square inch there would be room for one hundred and ninety six millions of these rods.

The cones are about three times the thickness of the rods and somewhat shorter. They are scattered unevenly through the rods, being placed more widely apart near the crystalline lens and getting closer together as they approach the centre of the retina, while at the very centre, that is, directly opposite to the centre of the crystalline lens, there is a small space of about one-thirtieth of an inch in diameter where there are no rods but only cones packed as closely as they can fit. The cones here are smaller than elsewhere, being about one-ten-thousandth of an inch in diameter. Ten thousand of them could stand on a little square of which the side was one-hundredth of an inch.

With each of these rods and cones connection is made by means of nerve fibres, and from each of them the nervous vibration or tremor caused by the light is conveyed through the optic nerve to the brain. Thus, when an image is made by the crystalline lens bringing the light to a focus on the retina, every particular of this image, all its little variations of brightness and colour, are instantly reported to the centre by millions of minute telegraphs, and if it moves on the retina all its motions are in like manner signalled as one rod or cone ceases to signal and another begins, so that every character and every change in the object produces its effect at the centre.

The effect is not, however, equal all over the retina. It is greatest when the image falls on the centre, directly opposite to the pupil, which is the spot where the image of anything which is directly looked at is formed. If the gaze is fixed on something right in front it will be noticed that what is directly looked at is very distinct and clear, but that other things get more and more indistinct as they are farther from this point. If some small object is looked at, first held directly in front and then moved round to the side without letting the eye follow it, the change in its distinctness may be very easily perceived. If an unfamiliar object stands far from the centre it will be seen that something is there but it will be impossible to say what it is. But although the shapes of objects can hardly be made out except when directly looked at, any motion is at once perceived even at the very verge of the field of vision, and when the motion is noticed there is a tendency to turn the eye towards it and look straight at whatever is moving.

When we look straight at any object its image falls on the central spot where, as we have already said, there are no rods, but only cones, and those of small size and closely packed together. Here the retina is thinner than elsewhere, for here there is hardly anything else than the cones and, therefore, they are more directly open to the light. When we notice that distinctness of perception increases in passing from the edge to the centre, that this increased distinctness is accompanied by an increased number of cones, that at the central spot there are no rods, but the whole space is occupied by cones and that here vision is most distinct, we cannot doubt that it is part of the plan of the human eye that distinct vision should not extend over the whole retina but should be confined to one small spot.

Now it might easily have been otherwise, for undoubtedly the image which is thrown on the retina is good and distinct over a far wider range than any photographer's camera can take in. It may often be noticed that when the photographer attempts to take in a very wide view the edges get somewhat distorted. The straight line of the corner of a house is represented by a curve and nothing is quite its own shape. The reason is that the lens has its focus everywhere at the same distance from the glass, so that the image which it forms is a curved image. But the photographic plate is flat, and although this is of no importance in the centre of the picture where the difference between the curved surface and the flat surface is small, yet towards the edges it begins to distort the image and, indeed, puts a limit to the width of view that can be taken in. But the surface of the retina is curved, so that it is able to receive the image without distortion for a very great distance from the centre. If it were taking a photograph, that photograph would be good for nearly half the horizon. Moreover, we have seen that the correction for spherical aberration is made by increasing the density of the lens towards the centre, and this correction is good for rays of light passing through the lens in any direction. So that in every way the part of the eye that acts as a camera seems fitted to give a clear image of a very extensive view. If, then, clear perception is confined to a small part of that view just in the centre it is because the retina is so constructed as to give us that and nothing else.

This restriction of clear and distinct perception to a small area is so far from being a defect that it is a great perfection in the eye, because it makes our way of seeing suit our way of thinking. It concentrates our attention upon one point at a time, and it is by concentration of attention that all good thinking is done. By not having too much to notice at once we are able to notice it effectually. It makes an impression on the memory and becomes part of our knowledge. The less distinct perception that we have of what is round about the clear spot that we are looking at helps us too. For we are always moving the eye to see distinctly what is next that spot; we are always looking up and down, backwards and forwards over anything that interests us. The eye, in fact, is always in motion. And we are conscious of that motion because we feel the action of the muscles that move the eye, and also because we are conscious of the motion of the image on the retina as the eye travels from one point to another, so that we are always drawing lines over the shapes and outlines of the things we look at and thus making ourselves thoroughly acquainted with them.

Nothing shows us better how thoroughly the human eye is fitted to serve the human mind than the fact that very few people to whom it has not been expressly pointed out have the slightest suspicion that they can see clearly and distinctly only a small spot at a time, and even when it is pointed out most people find it extremely difficult to see that it is true. They seem to themselves to see a very wide space in front of them with great clearness and distinctness.

The reason of this is that we put into the things before us not only what we actually see with our eyes but what we know to be there, and we seem to see it all. When a mother sees her baby toddling over to play with a red-hot poker she catches it up in an agony of apprehension because she sees that the poker is hot enough to burn the child. Yet she does not see the heat of the poker, for heat cannot be seen, she only sees the colour and glow by which she knows that it is hot. In the same way we see that things are hard or soft, that they are rough or smooth, that they are wet or dry, because we know by long experience how things look when they are hard or soft, wet or dry. It is almost impossible for anyone to distinguish between what he actually sees at the moment and what he knows and remembers about the thing he is looking at.

And amongst the things we remember best are the things that we have often seen. When we know these things very well we seem to see them before us. The sailor sees the shape and size, the rig and course of a ship where the landsman only sees a mark or two on the horizon. The sailor's sight is not peculiarly good, but he knows so well the shape of all the parts of the ship that although he really sees only two or three lines he puts the rest in and sees the ship as he knows it is. But there is nothing that we know better than the appearance of the thing we have just looked at, and so as the eye moves about we do not let everything drop as soon as we look away from it but continue to see not only the one distinct spot but a great deal that lies on every side around it. Thus it is only after much consideration and many efforts that we are able to notice how little the eye can clearly distinguish at once.

We are not at any disadvantage on account of the small size of the area of clear vision even when we go in pursuit of game or have ourselves to try to escape from enemies. All hunters and naturalists tell us that from their observations they are sure that timid animals, which must save themselves from their enemies by rapid flight, are always on the look-out for anything in motion because movement is their danger signal, and that beasts of prey are also on the look-out for moving objects because it is when in motion that they notice their victims. Now, although it is but a small part of our retina which gives us accurate knowledge of form and colour, the whole surface is very sensitive with regard to motion, so that even up to the very edge of our field of vision we are at once conscious of any kind of movement. Thus, whether we are the hunters or the hunted, our eyes are so constructed as to be thoroughly useful to us.

Enough has been said to enable any reader to take in the minute and complex construction of the eye and the wonderful way in which it is planned to suit our needs, and yet, perhaps, he may be able to take it in better if a few words are added on two questions which are sure to excite the curiosity of everyone who learns anything about the construction of the eye. The first of these is, How does it come that we see things the right way up although the image in the eye is reversed?

It is easy to see that the eye, like the photographer's camera, makes its image upside down, but we do not see things upside down. There are two ways of explaining this, but they both begin by pointing out that we do not see the image that is thrown on the retina. The difficulty really arises because we imagine the image at the back of the eye and another little eye looking at it from the inside of the head. But that does not in any way represent what happens. We have nothing to make us conscious of the image as a whole, but the separate rods or cones on which each part of the image falls send off their report of the effect produced on each separately. These messages are carried into the brain by the little threads of nerve-matter, and there they give rise to sensations of sight and there is a consciousness of the object perceived. What we see, then, is not the image that is formed in the eye but the object that stands before us. The image is only a means by which we see it.

One way of explaining how we see things upright depends on the way we always refer all our sensations to a point as far away as possible. We don't hear a sound in the ear, we hear a bell ringing far off. If we try to find something in muddy water by groping with a stick we feel the bottom of the pool with the end of the stick and refer all our sensations to the spot we are examining. In the same way we refer the sensation caused by the light from each part of the object looked at, back towards the object in the direction of the place it came from. That is what we mean by seeing it, and it means that when we see it we see it where it is.

There is, no doubt, a good deal of truth in this, and yet it does not explain everything. When we look at ourselves in the glass we see ourselves reversed. Left is put for right and right for left; writing or printing held up to the glass shows backwards, and if we move a hand to the right the corresponding hand in the glass moves to the left. Now this is extremely puzzling to anyone who tries for the first time to guide himself in doing anything by what he sees in the glass. If he takes a pair of scissors and tries to cut a particular hair at a spot which he selects he finds his hand moving the wrong way in the most aggravating fashion. He chops at the air far off instead of clipping a hair close to his face, and it almost feels as though there were some solid obstacle which kept him from getting right. But after a little all this difficulty vanishes and men shave themselves before the glass day after day without noticing that they have learned to move their hands to the right to make the image in the glass move to the left. The simplest way of constructing a telescope makes the observer see everything upside down and, for ordinary use by persons such as seamen, who only use the telescope occasionally and for a short time at once, it is found necessary to insert an additional glass, which turns the image round so that things are seen in their proper positions. But astronomers and surveyors are obliged by their occupations to use a telescope sometimes for hours continuously and in their case it is found that they get used to the reversed image and that it makes no difference, so that it is better and wiser to introduce no needless complications into the instrument. Therefore the telescopes used in observatories and those placed in surveyor's levels show everything upside down. From these analogies it is argued that it would make no difference to us whether our eyes showed things upside down or the right way. In fact, there is no other meaning to be given to the statement that we see things as they are, than that we see the connection between the way we see them and the way we feel them, so that the one reminds us of the other. What is it that comes to pass when we get used to doing anything before the glass? Is it not that the way we see it reminds us of the way we feel it? Now what would happen if our eyes were suddenly altered so as to form the image on the retina erect and not upside down? At first we would be in utter confusion, stumbling at every step and quite unable to guide our hands towards anything except with many trials and failures. After a few days we would be able to get on slowly and with caution, but pretty well on the whole. At the end of a month we would be able to do everything as usual and might even begin to forget that any change had been made. That, at least, is what I would suppose to be probable, and, therefore, I would say that it does not matter how the image falls on the retina provided that it always falls the same way so that we can get thoroughly used to it.

The other question which is asked by those who have newly learned something about the eye is, How does it happen that we do not see things double when we have two eyes? They are generally astonished at the answer, which is that we do see things double, and, indeed, that at every moment we see a far greater number of things double than single. Many people find it hard to believe this, especially as they are not able at once to convince themselves by experiment that they ever see anything double except when they squint. However, it is true, and anyone may come to see it if he has a little patience and will make a number of trials. The rule is that anything which forms an image on corresponding parts of each eye is seen single, but when the image falls on different parts in each eye the thing is seen double. Now what we are directly looking at throws its image on the central spot and is seen as one thing, but since the eyes are a little way asunder everything outside the little area directly looked at must form an image on parts in each eye which do not correspond and, therefore, must show double, and this is especially the case with things before or behind the thing directly looked at. Hold one finger up close to the eyes and look at something distant. The finger will show double. Now look directly at the finger and the distant object will appear double. Some people find it very hard to perceive this. The reason is that our attention is concentrated on what we are looking at directly, and everything else makes so slight an impression on consciousness that it is hardly perceived. An experiment of this kind is a practical lesson on the difference between seeing and perceiving. These double images, although they make so little impression on consciousness, are of great use to us, for they enable us to distinguish between things which are in the same line but at different distances. The thing we look at is single and the others are double, and when we look from one to the other the change from single to double and from double to single gives us a clear idea of their relative positions. It will be easy to find instances in which it is very hard to tell which of two objects is nearer with one eye shut and very easy with both eyes open, or this experiment may be tried: Place on the table at different distances several small bottles without corks. Now, with one eye shut, try to put a pencil into the neck of one of the bottles. It is a little surprising to one who tries it for the first time to find how apt he is to go wrong with one eye open and how easily and accurately it is done with two.

From this account of the mechanism and working of the eye it will be seen that it has a very elaborate arrangement of parts, which are so disposed as to perform functions of great importance by the way in which they fit into one another and work together, and by the way in which they correspond at the same time to the working of our mind and to the nature of light. And it will be felt that all this fitting and correspondence, all this working together of various parts, must have been brought about by some intelligence that could look forward and foresee how things would act. This plan and construction came at some time into being. There was a time when it was not. And it never came into being merely by chance. One chance or a million chances, it is all the same. We cannot suppose things blindly jumbled into an order such as this.

We have, moreover, to reckon on the action of Natural Selection, always ready to welcome small improvements, but thereby always putting obstacles in the way of radical change. Every organ in the body has its own work to do, and the part of Natural Selection is to keep every organ efficient and thereby incidentally to prevent any one, say an organ of feeling, from changing to work of another kind and becoming, as is frequently suggested, an organ of sight. Let me illustrate this by a story. When Peter the Great had finished his new capital of St. Petersburg (now called Petrograd) he was in such a good humour that he resolved to confer upon the first ship that entered the port the privilege of bringing in its cargo duty free as long as the world lasted. But when it was represented to him that as ships do not last very long his bounty would fall far short of his intentions he altered the terms and allowed a new ship to be substituted for the old one from time to time provided always that the new ship should be carefully inspected by the harbourmaster to see that it was practically the same ship as the last, with none but small improvements admitted into any part of it. The Czar's instructions were duly carried out and the first vessel being a sailing ship (as all ships were then) of a rather old-fashioned type was replaced in a few years by one more up to date, and every time a new ship was built small improvements were made in hull and rigging so that in time the favoured vessel became a paddle steamer, then a screw steamer, and it is at present as smart a turbine steamer as trades to any port. Perhaps I may be asked here to explain how any imaginable accumulation of improvements in sails could turn them into paddles. Well, I cannot quite explain, except that I have seen on a windmill a sail that went round like a paddle-wheel and might form a sort of link between them. "*But is the harbourmaster supposed to have carried out his duty of inspection with strictness and accuracy?*" Certainly he was always most particular. "*Then the sails could never have been windmill sails or anything but efficient ship's sails and these could never by any process be improved into paddles.*" I suppose I must give up my story as a true story, but perhaps I may keep it as a parable, for if the harbourmaster's inspection would prevent ship's sails from turning into paddles surely the more stringent requirements of Natural Selection would keep an organ of feeling, which was used as an organ of feeling, from turning into an organ of sight. As for an organ of feeling, not used and so thrown out of selection, its portion could be nothing but disintegration and decay. We will hardly be asked to accept the decay of feeling as the reason for the beginning of sight. If paddle-wheels cannot begin to exist as efficient sails neither will decayed and dilapidated sails produce them.

CHAPTER XVII

AN INSECTIVOROUS PLANT

In testing scientific theories we must never shrink from the use of the imagination. We must always try to picture to ourselves how things would look, and to see how things asserted to be true might possibly have happened. In proportion as a theory enables us to build up a model of what is, or to realise a possible way of the coming about of an event, we may feel that we are allowed to test and examine it to prove it true or false: in proportion as it retires into a jungle of words or a dance of symbols, and refuses to become a picture in the imagination, we may feel that it eludes our touch, evades our test and escapes our judgment. For every word, sign, or symbol that has a true and positive meaning is the servant of the imagination, and is ready to yield its treasure at the bidding of its master. What cannot be imagined is certainly not understood. We shall now, therefore, try whether we cannot make a study in evolution and picture to ourselves the coming on of a transition, or if the actual change escapes us, as well it may, since our knowledge of such things is but small, we shall try to get as near it as we can on either side, so that we may judge what manner of change it was.

We take, then, a little green plant growing freely in open situations, and preferring those on which there is no lack of moisture, a hardy and vigorous little plant, but one in no way remarkable, growing as other plants from the ground and the air, and seeding freely every summer. Then we imagine a gradual change in the climate making the place where this plant grows continually moister, until all its favourite haunts have become swamps, morasses, turf-bogs, or watery heaths. We suppose the change to come on so slowly that any plant which can adapt itself to the new conditions shall have time to do so, and we try to picture what will happen.

We know that many of the plants in that region will altogether die out. There are always a number of species in every locality that are barely able to maintain themselves, and any change for the worse in soil or climate is sure to put an end to them. They have not vigour enough to make a fight against anything more unfavourable than their present surroundings. We must suppose, however, that our little plant is not one of these. It does not at first find an increase of moisture unfavourable to its vitality, and by the time that the moisture has become so great that it would have found it impossible to live, it has acquired a new way of maintaining itself.

The plants which find wet and boggy ground peculiarly suitable to their constitutions will increase in number and spread on all sides. Some of these no doubt will already exist in the lower and wetter parts of the country, and some may come in from surrounding districts. Plants send their seeds far and wide, and have many carriers which are always bringing them into distant places, and any district which offers a welcome will soon be filled up by a multitude of immigrants. Thus water plants would multiply where running or stagnant waters offered them a home, and air-feeding plants would rest on places where the water-logged soil refused to do its part in sustaining vegetation. Every variety of swamp or marsh would find itself clothed with its appropriate vegetation, and all these, whether natives or intruders, would combine to eject those plants which had occupied the ground before the climate became so wet. Many of these plants, therefore, which might have endured the change of climate if it stood alone would certainly be vanquished by more vigorous competitors better fitted for the place under its new conditions. But our little plant is not one of these. It still holds its ground, doubtless much reduced in number, and every year gradually yielding a little more to its competitors, but still vigorous enough to show some promise of a future.

In a place where the conditions of life are changing as we have imagined, many plants will be found to respond to these changes. For there is in the nature of living things a certain power of responding to changes in their environment. The changes to which plants most readily respond are changes of temperament and moisture. Their response does not merely consist in showing the natural and necessary consequences of the change as they do when they thrive and flourish on an abundance of nutriment and grow stunted and attenuated in consequence of starvation. It is some change in the plant which arises in consequence of the change in the environment, and also makes the plant better fit for the new conditions of life. This is no natural and necessary consequence of the change; it depends on the construction and constitution of the plant. It is no necessary consequence of increasing dryness that it should make plants fitter for living in a dry place. But it is part of the plan of the plant, it belongs to the design on which it is constructed, that it should be able, when the air and the ground get drier, so to alter its way of growth as to be better able to thrive on dry ground. And again, the same plant will be able, when its surroundings change once more, to fit itself to a damper place. The changing circumstances do not change the plan of the plant, they only bring to light the possibilities which it contains.

A vast number of species have in the course of their evolution acquired this power of responding to changes in environment, and some of them possess it in a very high degree. In the desert will be found many plants, having small leaves or none, covered with sharp and hard thorns and having a hairy surface, and many of them, when removed to better and less arid ground, will lose their thorns and hairs and acquire leaves resembling the plants which naturally grow in that place. And many of the plants which grow near the desert may be moved into it, and will be found to live by assuming the appearance and way of growth of desert plants. In the same way the thick, fleshy and leathery leaves of plants which grow in salt places often become thinner and softer when they are removed to places where there is no salt, and many plants when treated with salt are found to be able to develop thick and leathery leaves.

There is the same relation between marsh plants and plants that grow in the neighbourhood of marshes, and the same possibility of bringing about changes in the appearance and habits of the plant by changing its surroundings. But we cannot say that it is a law of Nature that the dryness or dampness of the environment should produce certain definite effects on vegetable tissue. For the response of the plant has not the uniform and inevitable character which denotes a law. Some plants respond readily, and some do not respond at all, but perish if the environment changes. This looks like a case of adaptation; the one has become adapted to change, the other to stability. Some plants defend themselves against drought by hairiness of the surface, some by waxy secretions, some by sending out roots on all sides to seek for moisture. If it were a law that dryness had a certain effect it would have the same effect on all, but if they have acquired an adaptability it is in accordance with the analogy of Nature that it should be acquired in different ways by different species. Aquatic plants have loose tissues and weak, flexible stems, and it is suggested that this is the necessary effect of an abundance of water. But reeds grow up from under the water with stems as hard and stiff as if they had grown in a dry place. The natural inference is that neither the stiff stem nor the weak stem is any necessary result of growing in water, but that they are both adaptations acquired by the plants as the result of their respective evolutionary histories. And as climates have always been changing from the beginning, most species of plants have acquired and retain the power of adapting themselves to changes of climate.

And so we must suppose that our little plant has adapted itself, so far as its plan allows, to the moister climate in which it is now growing. But nothing in its plan is quite equal to the occasion. It cannot become a regular aquatic plant, nor can it become one of those that grow from the air. These forms are only assumed by plants which have the possibility already included in their organisation. We are not now considering their first origin; they are already in the world. The plants which are able to do so will make these adjustments, but our little plant is not able.

And so our little plant seems to have no future before it except to become scarcer and scarcer as it is thrust out of existence by more vigorous competitors, until very slowly it dies away and the species becomes extinct. Indeed, its extinction is almost in view; its dwindling roots are bringing it less and less nitrogenous materials from the soil, the water-logged soil is giving them less and less encouragement, and there are now only a few places where the plant can grow at all. But one day one of these plants develops a new thing in the world; it catches an insect and digests it.[1] The next day several others in the neighbourhood do the same, and the plant is saved. It has found a new source of nutriment, by the help of which it can grow in turf-bogs, on watery heaths, and in other places, where its roots can gain for it little more than moisture. From that centre it can increase and multiply and spread over the world.

But how are we to imagine this coming in of a new plan, this beginning of a way of gaining a living that the world had not seen before? For this is the first time that any plant has caught and digested an insect. How can it have come about? What possible steps can have led up to it? What chain of variations can we imagine that would end in this? Before we can even attempt to answer these questions we must examine our insect-eating plant as it is found at the present day. It is probably changed a good deal since that day on which the first insect was caught and eaten, but still we may be sure in all essentials the plan will be the same.

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[1] *One day*, because you cannot imagine anything half-way between catching and not catching.

The examination of the plant presents no difficulty, for it has been carefully examined already by one of the most competent observers that the world has ever seen. In one of his works[1] Darwin has devoted two hundred and seventy-seven pages to a description of the properties and manner of growth of the little plant we have been thinking about. It was to him so strange and wonderful a thing that a plant should catch an insect and digest it that he studied, observed, and experimented with it until he had ascertained what it was able to digest, how it digested it, how its functions were excited to activity, and how it would behave under a great variety of conditions which he devised. The result is that there are few things in nature which have been more carefully and accurately described than the way the Sun-dew has of eating insects.

The Sun-dew (*Drosera rotundifolia*) is a little plant with from two or three to five or six small leaves, and but poorly supplied with roots. The appearance of the leaf is given by Darwin as in Figs. 15 and 16. This leaf is the instrument by which insects are caught and digested. The upper surface is covered by a set of little hairs averaging something less than two hundred to a leaf, each of them supporting a gland which is covered by a drop of sticky matter. This gives the leaf the appearance of being covered with dew, and to this appearance it owes its name. Insects are caught by being entangled in the sticky substance on the glands. When caught they struggle for a while, but they soon get covered with the sticky substance, and are thus suffocated and killed. But their struggles have an effect of some importance to the plant, for the glands receive an impulse or stimulus from frequent contact with small substances, which is communicated to other hairs at a distance so that they all begin slowly to bend towards the insect which has been trapped. Wherever the insect may be, the hairs bend towards it from all sides, but those on the edge of the leaf are longer than the others, and if it is near them they go on bending after they touch it, and those beneath turn over towards the middle, so that an insect caught near the edge will be transferred to the middle of the leaf.

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[1] *Insectivorous Plants.* By Charles Darwin.

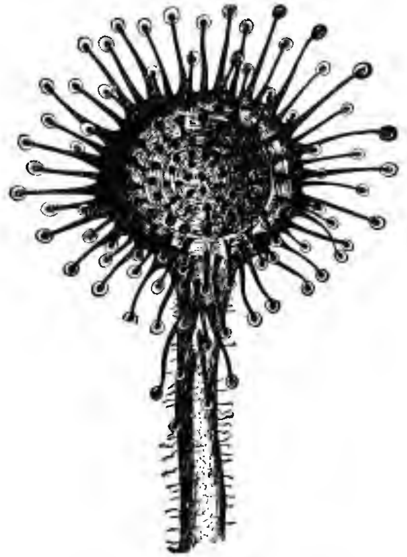

FIG. 15.—DROSERA ROTUNDIFOLIA.
(Sun-dew).

Leaf viewed from above enlarged four times.

From Darwin's *Insectivorous Plants.*
By kind permission of Sir Francis Darwin.

In the course of four or five hours all the hairs on the leaf may become bent down, so as to come in contact with an insect which has been caught. They will remain so pressed down for some days. The secretion will be formed more abundantly, and will become more acid. It will have the effect of digesting the greater part of the insect, and will be absorbed by the surface of the leaf, and will so carry into the substance of the plant the matter which it has digested and dissolved. When the operation of digestion is finished the glands dry up, the threads slowly return to their usual position, and wings, scales, or other indigestible parts of the insect may readily be blown off the surface of the leaf. Then the secretion is formed again and the leaf is ready for another insect.

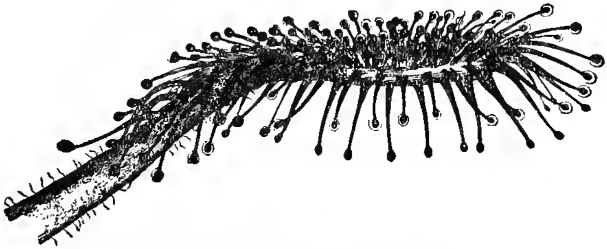

Fig. 16.—Drosera Rotundifolia.

Leaf viewed laterally, enlarged.

From Darwin's *Insectivorous Plants.*
By kind permission of Sir Francis Darwin.

The glands are affected and stimulated by mechanical contact with small substances, and also in a greater degree by contact with digestible substances. If they are excited by an indigestible substance, such as a fragment of glass, they do not remain long bent down over it. It causes the beginning but not the continuance of the process. Nothing but the presence of something which the plant can digest gives the necessary stimulus for that. The regular course of events seems to be that the insect's feet coming in contact with several glands gives the stimulus which sets the apparatus working, and then from the process of digestion, when once begun, comes an additional stimulus which keeps the leaf at work until digestion is completed.

The process which goes on when the Sun-dew catches an insect is a real digestion. The body of the insect does not decay. It is often held so long in the leaf that a dead fly lying on the leaf of an ordinary plant would be very far gone in decay, but the digestive fluid has an antiseptic property which prevents decay in the insect which it covers. In fact, the digestion of an insect on the leaf of this plant is a process of the same kind as the digestion which goes on in the stomach of an animal. There is a ferment like pepsin, and to this is added an acid, just as in animal digestion, and these are yielded by the glands on the hairs in response to the stimulus given by contact with digestible matter. All plants can through their roots derive nourishment from decayed animal substances, but here the substance is fresh and is not allowed to decay, and the nutriment is absorbed through the leaf. It is easy to understand how the Sun-dew is able to grow in places where its roots can bring it nothing but a supply of water.

This general description of the way Sun-dew has of maintaining its existence is sufficient for our purpose. In Darwin's book will be found an elaborate enquiry into the precise nature and exact limitations of its powers of motion and digestion. What we are concerned with is the fact that it regularly catches insects and lives on them. With this fact before us, we return to the question already propounded, and ask how we are to imagine its way of coming to pass.

We cannot imagine that there is anything in the conditions existing previously which would produce it. A plant which grows in the ordinary way out of the ground and air has no machinery in its constitution—has nothing in its plan—which would enable it to live on insects. No shifting of parts, no change of working possible within the limits of its plan, would bring such a thing about. There must be for that the introduction of a completely new contrivance, just as no shifting of the parts of a water-mill would make it into a wind-mill, and as neither a water-mill nor a wind-mill has in it the plan or the makings of a steam-mill, so the ordinary plant that grows in the usual way has not in it the plan or the makings of an insectivorous plant. But the water-mill or the wind-mill may be changed into a steam-mill if a steam-engine is brought and added to it, and so may the plant by an addition to its plan be made into an insect feeder.

An addition to its plan, a new piece of machinery added to it, is precisely what we find. Whence are we to suppose that it comes? May we say that it came because it was needed? We cannot find anything in Nature to justify us in taking it so. To an intelligent being no doubt necessity is the mother of invention, but necessity is no inventor; much less does the want of anything produce an apparatus for getting it. It would be very absurd indeed to think that the want of nourishment so altered the plant as to make it able to live on insects.

It comes to this, then, that we must imagine all this new apparatus to have come by chance or to have been produced by design. We must see in it the work of an intelligent being or the mere haphazard falling together of material particles. But we cannot possibly imagine material particles falling into new designs without intelligent guidance. If they are not guided by intelligence they can only continue to move according to whatever plan or arrangement they possess, or else, if they are driven out of that, fall into confusion and disorder. This point has been dealt with at length already; we need only now refer to what has been said about it. But it is worth while to pause for a moment and note what a monstrous demand is made upon our credulity when we are asked to imagine that all this came about by chance.

In the first place, the insect is caught. Now an insect may be caught by chance; indeed, insects are so caught by the sticky buds of the horse-chestnut. But the sticky substance which catches the insect is of use to the bud, and the insect which is caught is of no use. The case is similar to that of a quicksand in which an animal is swallowed up and perishes without doing the quicksand any good. Or it is like the case of the gnats which are caught and killed by a newly painted fence, and often much disfigure the paint. These are accidental occurrences, which are plainly seen to be such. They have no mark or appearance of design, but show two things coming together whose coincidence was not part of any plan. But the sticky secretion of the Sun-dew which catches the insect also digests it; the thread which holds the drop of sticky substance bends down upon the insect and also pushes it to the centre of the leaf, and a stimulus is sent out on all sides, causing the other threads all around to bend in towards the insect. These adjustments all come together as part of one plan. Can we imagine them all to spring up by accident simultaneously, to come into existence in one day? It is enough to ask such a question. The absurdity of the suggestion is too great to deserve consideration. Then we must imagine that the various parts of the contrivance appeared one by one at first in a faint, imperfect way, and then by degrees in a more and more efficient form. First we imagine little sticky drops not able to entangle an insect, but only to annoy it. Then they get bigger and more sticky, until the insect is caught, but without doing the plant any good, and then a little digestive liquid is produced which gradually becomes more abundant and stronger and so on. Yes, but why are we to imagine the sticky drops coming and waiting and increasing while yet they are of no real use? Is it not the office of Natural Selection to prevent anything waiting or increasing that is of no use? If the digestive powers did not come at once they would find the stickiness gone, and there would be nothing to digest. So that we have done violence to our intelligence in vain. We have compelled ourselves to imagine a bit of the new plan coming by chance, and then we find that it is of no use, for we must have all or none. We cannot imagine this new contrivance as coming by chance, whether we try to make it come altogether in a moment or take it bit by bit and let it come in gradually.

But if we allow a conscious intelligence, which looks forward to the future and provides for it, to be concerned in the matter our imagination moves freely. The plant is helped over a difficult crisis in its history, a new contrivance is introduced, and it enters on a new era of prosperity. The new contrivance comes from the source of all contrivances, that is, from conscious intelligence, and is for ever a sign and proof that the evolution of the plant has been directed by an intelligent designer.

We are not even compelled to imagine the intervention in this particular instance of an intelligence greater than our own. We know not, of course, what power may be required to make vegetable tissue so plastic that it may be compelled to assume new forms and adopt fresh ways of growth, perhaps we may never find out how this is managed, but if we had this power we might certainly design new plants, such as the Sun-dew, and set them growing by forming them out of other suitable plants already in existence. And thus we are not debarred from supposing that the Almighty may have committed the working out of the evolution of this plant to some subordinate agent.

But I would not use any such supposition for the purpose of warding off the common objection to our way of looking at Nature, that it assumes without good reason that the relation of God to the world corresponds to the relation of the workman to the thing he makes. In answer to that objection, I would rather say that I can see nothing mean or degrading in the relation of the workman to his work, nothing, indeed, that may not with due reverence be applied to the Almighty. But our enquiry is not concerned with the details of the work of making the world, but rather with the general fact that, as made the world everywhere exhibits marks of design. We are perpetually coming across something that reminds us that we do not know how things were made, but we are just as often assured that we do know how things were not made—they were not made by chance. Our contention is, in fact, that the world can be interpreted, that it yields a meaning. If anyone denies this, then, so far as he is concerned, there is an end of this question, but there is equally an end of all questions. Nothing remains for him but the blank night of universal ignorance. But if the world can be interpreted, then it is a reasonable world. There is only one kind of reason, and we are the possessors of reason. Thus we are able to recognise the marks of reason when we meet them, to say : this is the work of intelligence, this did not happen by chance ; the world has an intelligent Maker, and that Maker is God.

CHAPTER XVIII

A BIRD'S FLIGHT

THE faculty or power of flight has appeared four times, in the course of evolution as known to us, or five times, if the flying-fish is regarded as possessing the power of true flight, and not merely a superior kind of gliding. The four cases in which it has certainly appeared are the flying reptiles, now only known as fossils, the bats, the birds, and the insects. And in each case the evolution of flight was absolutely independent and original, that is to say, we cannot take any one of these classes of flying creatures and say that its flight is derived or learned from any of the others, or dependent on it in any way. If we try to trace back the line of descent of any two flying animals of different kinds until we come to a common ancestor or to anything which a zoologist would accept as being with any degree of possibility a common ancestor, that ancestor will be found to have no wings and will show no signs of flying. Birds are evidently derived from reptiles, but not from the flying reptiles; the two lines of descent can only be made to come together at a time when no reptile had yet acquired the power of flight. Moreover, the plan of a bird's wing is in many ways essentially different from the plan of a reptile's wing. The bat's wing is indeed very similar in plan to the reptile's, but the bat is much more distantly related to the reptile than the bird is, so that in the two wings we have an example of a similar design followed by two absolutely independent lines of evolution. The case much resembles the evolution of the eye in the molluscs and in the mammalia, except that this latter is more striking, as occurring in animals so differently organised in other ways and so very remotely connected in the system of evolution.

The power of true flight, then, has been gained four times in the history of the world, or possibly five times, and in each case it gives us a separate and independent instance and argument of design. But when we put the four cases together they come to much more than the sum of four instances. They have a cumulative force when taken in connection, which is greater than anything we can find in them when taken separately. Here is a great step made, an important additional power given to a special class of animals. It opens new possibilities and enables them to inhabit a new area. It gives them the power of surmounting obstacles hitherto impassable, of escaping from enemies which might have threatened their extinction, of finding new resources in times of scarcity, and additional opportunities of extending their racial habitations. It is an altogether desirable change. But before it occurred there was no power in the animal to imagine or desire it. There was nothing to turn in that direction any strivings or longings for safety or plenty that might have been felt. We know well what animal intelligence is capable of, and we know therefore that it is not in its highest form at all capable of imagining or striving after a new way of life. Nothing less than fully developed reason can do that. There was therefore no power derived from the past history of the animal which could urge or propel the course of evolution in the direction of flight. If the direction had been spontaneously taken it would have been taken by chance. That such a thing should have happened once by chance is surely incredible enough to stagger even the most careless reasoner; that it should have happened at least four times ought to be conclusive. There is in all our experience so marked a difference between the direction and guidance which may come from what has happened in the past and that which arises out of the foresight which prepares for the future, that it is not easy to understand how it is possible for anyone to miss seeing in any single instance of the evolution of flight a clear indication of design, and here we have the combination of four or five instances.

In the acquisition of flight we have something even more than a passage into a new state of existence, we have the acquisition of new and complicated organs. The whole structure of the animal must be varied to suit its new way of life and to make it possible for it to use its wings. The adaptations necessary are so many and so varied and depend so much on one another that it is impossible to think of them as brought together by chance. There must have been direction. Foresight must have been used in bringing them about. A very high degree of intelligence is necessary to account for them. If we are to think coherently and to explain what we see by what we understand we must confess that this thing is quite intelligible if regarded as arising from design, but absolutely unintelligible on any other supposition. To bring this out more clearly we shall consider one of the cases of the evolution of flight, taking the bird's flight as the best known and most interesting example.

Those who are not acquainted with the recent progress of Science may take it as an established truth that birds are descended from reptilian ancestors. We cannot, indeed, make out the pedigree without immense gaps and enormous transitions, but every indication that can be trusted goes to prove that this is only on account of the imperfection of the records on which we rely. No competent naturalist can doubt that if a complete set of fossils could be obtained they would show a regular and gradual transition from the reptile form to the bird form.

What we have falls far short of this. The earliest bird form with which we are acquainted is that called the *Archæopteryx*, represented by two fossils from the lithographic state of Solenhafen, in Bavaria, a rook which belongs to the Jurassic system. There are no intermediate forms between this and the reptiles, and it is true bird. But it has many reptilian characteristics, of which three have attracted great attention. It had three teeth on each side in the lower jaw and thirteen in the upper, and it had a long tail like that of a lizard. This tail had twenty vertebræ, from each of which sprang two fully formed feathers. No bird at the present day has any features resembling these. The third and perhaps the most important characteristic was the true reptilian hand, showing the metatarsal bones distinct and not fused together as in the present type of bird. This hand, besides supporting the wing feathers, had three claws fitted for grasping.

In other respects the *Archæopteryx* was a true bird. It had well-formed bird's feet suited for perching on trees; it had well-developed feathers. It must have been able to fly almost as well as a rook. We would certainly like to find something nearer the reptile ancestor of birds, but what we have is near enough to remove all hesitation about accepting this as their true line of descent.

The next bird fossils are separated from the *Archæopteryx* by an immense interval of time. They show much progress. The long tail has been got rid of, although the teeth are still retained, but their form enables us to imagine how the old bird form gradually changed into the new, and how the birds of the present day have been derived from something older than the *Archæopteryx*.

It would be satisfactory to be able to find some fossil reptile showing approaches to a bird form, but nothing of the kind has been discovered. There are indeed some bird-like footprints, but nothing else exists to show what the animals were like that made them, and they may have been reptiles not in any other way resembling birds. They can hardly be what we would like to find, as they were large and heavy, and if they resembled any kind of bird they would resemble an ostrich. But ornithologists are convinced that all birds which cannot fly are degenerate forms derived from ancestors which could fly, so that the reptilian ancestor of birds must have been some small and light form, or at least that is what it must have been if while still a reptile it showed some approximation to the form of a bird.

And so we are left without any assistance from intermediate forms to ponder on the question which our subject presses on us. Is there any power known to us by which the evolution of birds could have been impelled or guided? Let us suppose the former existence of a series of animal forms passing through an immense number of intermediate gradations from a reptile to a bird. Can we suppose the series to have come into existence without the help of intelligence and design?

We have already considered the general question and argued, as the reader has been reminded more than once, that nothing can be added to the design of any organism; no new complication of parts or organs can come into existence without the intervention of a conscious intelligence guiding the arrangement of parts with regard to the future, that is to say, looking forward to the place each is to occupy with regard to the rest and to the function which it is thus to discharge. And it does not signify in the least whether the additional complication of order and arrangement is added all at once or by a long series of events bringing in a small piece at a time, for the presence of consciousness and design is equally involved in either case. To some persons the instance seems more impressive and the argument more convincing when the complication of parts is very great, so that they can say that the chances against such a thing occurring without design (if it could be supposed that there was any chance of its so occurring) must be infinitely great. It is also in the same way impressive to find that simultaneous changes in several parts of the organism must concur to produce the required effect. Now there are many changes which must have come about in the ancestors of our present birds during their passage from their former state as mere reptiles to their present as almost perfect flying machines. Some of these we can understand well enough to found a separate argument on each, some we do not. We can see, however, that there is no possible way in which they could all be brought about together, except through conscious foresight and design, and yet they appear to be so necessary that if any one of them were missing the bird would be very far from its present great efficiency.

To take one as an example, we find that reptiles are cold-blooded, but birds are warm-blooded. Now cold-blooded land animals are never capable of the vigorous and continuous exertion demanded from a bird. Fishes show great vigour, but any spurts of energy put forth by a cold-blooded land animal are of no long duration and are inferior in vigour to the actions of those which are warm-blooded. The contrast in this respect between birds and reptiles is very great. It will be noticed that a reptile is always apt to make a little run and then a pause, that it will not engage in any long-continued activity or go far from the place where it feels itself safe. Reptiles never course over the ground like deer or horses, keeping up a high speed for a long period. They never pursue their prey like wolves, or even keep up a strained attention when watching for it like cats. They live sluggish, inactive lives, and pass much of their time basking in the sun or lying motionless in the water. Birds, on the other hand, are capable of the most strenuous and long-continued exertion. Amongst those which are most familiar to us, the swallow seems never to rest while daylight lasts, and when the time of migration comes the distances it accomplishes are a wonder to all who trace its journeys. And even the quietest of our birds seem never to be quite at rest. If they do not go far they are always taking short flights backwards and forwards. They are as active and restless a race as can be found amongst vertebrate animals, and this appears to be connected with their having warm blood.

This property of having warm blood is in some ways still unexplained and mysterious. It does not merely consist in having blood warmer than the surrounding substances, such as air or water; it involves the maintenance of a certain definite temperature. Every kind of warm-blooded animal has a temperature of its own, and that temperature while in good health it maintains. It is always assisted in this by some kind of covering, skin, feathers, fat, or fur, so constructed as to be a defence against changes of temperature. Yet even with this assistance it is not easy to see by what mechanism the temperature is adjusted and kept as even as though it were controlled by a thermometer. Our feelings only tell us of relative temperature. We call anything warm that is warmer than the hand we touch it with, and anything cold that is colder, so that the same thing may seem hot to one hand and cold to the other; but there must be something in us sensitive to absolute as distinguished from relative temperature, which always acts upon the blood and keeps it at its proper heat. Now here is something which the ancestors of our birds must have acquired in developing their power of flight.

They must also have acquired the particular conformation of the heart which distinguishes birds from most reptiles. The general plan of the heart is a group of four chambers which expand and contract by means of muscles in their walls, and so form a pumping apparatus. Two of the chambers pump each into one of the others, being, in fact, ante-chambers by which the others are filled. The two others are the real pumping chambers by which the blood is circulated. Thus the heart consists of two pumps lying side by side. There are two pumps because there are two circulations. First, the blood coming back from its course through the body passes into one of the ante-chambers, and from this it is pumped into the chamber beyond. Then by this it is pumped through the lungs and on to the second ante-chamber. In going through the lungs the blood takes up the oxygen it needs and gets rid of the waste carbon dioxide with which it is loaded, so that it arrives at the second ante-chamber in fresh condition, showing a bright colour and ready to make its round through the body again. The second ante-chamber pumps it into the second chamber, by which it is propelled with such force that it makes the round of the circulation and comes back to the first ante-chamber again.

This is the plan of a bird's heart. But the characteristic reptile's heart is, as compared with this, but a very imperfect apparatus. The two pumping chambers of a reptile's heart are not completely separated, because the partition between them is not large enough to fill the whole space. Consequently when they contract some portion of the impure blood that has returned from the circulation passes from the first chamber directly into the second and gets back into the circulation without having passed through the lungs. When the contraction of the chambers has, however, proceeded a little way their walls are pressed in against the partition, which now makes a good division, so that from this point in the stroke no more of the blood which has not been purified by going through the lungs gets into the general circulation. For a bird this would be a very defective heart, but it answers to all the demands that the reptile makes upon it. The sluggish life of the reptile does not require to have its muscles fed with so much oxygen as is demanded by the active exertions of the bird. It may even be that the consequences of an over-supply of oxygen would be disastrous. Very possibly a reptile supplied with a heart of the bird's pattern would be unable to maintain its existence. But what we are interested in is the fact that we have here two types of heart, each working well for its possessor, and that the change from the one type to the other was one of the great changes which combined to make a reptile into a bird.

That this change might have occurred without transforming a reptile into a bird is evident; indeed, it has almost occurred in the case of the crocodile, which shows no tendency to become a bird, and yet has become possessed of a heart having four distinct chambers. But the mixture of a portion of impure blood with that which has come from the lungs is effected by communications between the blood vessels, so that the crocodile's circulation has still the reptilian character. But similar changes may occur in different species and take a place in the particular plan of each species, and in each case we are entitled to point them out as part of the sum total of change involved in the evolution of the species.

It is very probable that there are many other characteristics of the birds we know which might have been possessed by reptilian ancestors which were not birds, but they are all portions of the plan of the bird, and therefore it matters not when they were acquired.

Birds are very remarkable for the quick beat of the heart when flying. When resting, their hearts are found to beat much more rapidly than the hearts of mammalia, but a single beat of the wings is enough to set them going so rapidly that they cannot be counted. This is no doubt necessary to provide for the great muscular activity of the flying bird.

We have here a collection of important changes which have been brought about while the reptile was transformed into a bird. It is evident that to make all these come about and to make them fit into one another and occur simultaneously we must assume that the evolution was under the control of no mere blind striving or chance variation, but was directed by clear foreseeing intelligence. But all these together are really less in amount than that which is now to be considered.

The bird's flight depends on its possession of feathers. They are the implements with which it makes its way through the air. Let us see what sort of implements they are. We are, of course, only considering wing feathers, because we are thinking of a bird's flight. There are feathers which serve as a covering and keep out the cold. They are almost the same as the wing feathers, and they are a most efficient defence against the weather. There are feathers also which are ornaments and which are so successful as ornaments that we take them from the birds to adorn ourselves. But all these we must pass over and consider only feathers as used in flight.

The feather is in itself an extremely elaborate contrivance. It begins at the base with a cylinder or barrel of a semi-transparent horny substance, the part from which the nib of a quill pen is made. This part of the feather is very strong and very light. By it the feather is fixed in its place and held firmly on the wing. It contains the vessels by which the feather grows, which, when it is fully formed, shrivel up and become dry. We can find them in this state in any quill feather. Next to this barrel comes the shaft of the feather, which is of a square shape tapering to the point and slightly curved. Its substance is somewhat open and spongy, but if trial is made of it the whole shaft will be found to be very light, strong and elastic. It is this last requirement which gives us the reason for the change in the character of the shaft of the feather. The barrel or round part is stiff, the upper or square part is elastic. Together they form an admirable support for the vane or broad part, holding it out stiffly but not too stiffly when the wing is in use.

The web or blade of the feather is formed of a number of thin slips or shavings of horny material growing out of the shaft side by side. At first next the barrel will be found a few which are soft and downy, and then all the rest of the way to the end they are close and straight and stiff. They are thicker at one edge than at the other, like the blade of a penknife, and as they are set side by side on the shaft the thicker edge is on the outside, that is on that side of the feather which is turned out when the wing is folded. The shape of these slips, which are called the barbs of the feather, gives them their greatest strength in the direction opposed to the pressure of the air against the wing. There are a great many of these barbs on a feather. Even a small wing feather will have several hundreds. Anyone who takes a feather from the wing of a goose or a pigeon and sets himself to count its barbs will find his respect for a bird's wing as an elaborate and finished contrivance very greatly increased.

The feather constructed as described is a light yet strong and elastic implement contrived to beat the air in flying, or to rest on it for support when the bird is gliding. But for for this purpose the barbs must be held together so that the air shall not pass through between them. By being held together they become solid like a wall, whereas if they were loose they would let the air pass like a set of railings. It will be noticed that the barbs are held together in a very efficient way, so that the whole web or vane of the feather resists the air as one piece. If the finger is passed along it from the point to the base the barbs are pulled asunder and separated, but if they are smoothed down and pressed together they take hold of one another again. This may be done many times without injury to the feather. Thus a bird's wing can stand a good deal of knocking about without getting out of order or unfit for use.

The fastening is done by little hooks, which are so small that they cannot be seen except through a good microscope, and yet so numerous that they are able to hold the barbs firmly together. They are pulled asunder without being broken and reunited when pressed back into their places, because, like the rest of the feather, they are made of a horny and elastic substance. But these hooks are not attached directly to the barbs. To carry them there are first of all small pieces or barbules growing out of the barbs, just as the barbs themselves grow out of the shaft, and as the barbs while pointing outward at the same time point forward towards the tip of the feather, so the barbules point outwards from the barb and forwards towards its tip. These barbules are amazingly numerous. There may be as many of them on a barb as there are barbs on the shaft. The number on a fairly large wing feather would be well over a million. They are, of course, very small, hardly more than one twenty-fifth of an inch in length, but in shape resemble the barbs, except that the upper edge, instead of being thickened, is bent over into a sort of roll.

As the barbs lie closely side by side and the barbules grow out of them the barbules of each barb cross those of the next, and as while stretching outward they slope forward each barbule crosses several from the opposite row (Fig. 17).

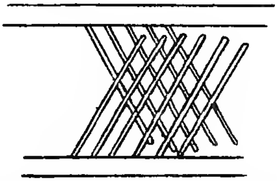

FIG. 17.—Diagram showing how the barbules cross.

The barbules which point towards the base of the feather are simply straight slips of horny material turned over at the upper edge into a roll, but those which point towards the tip of the feather from about the middle of their length to the end grow into little hairs or threads which are called barbicels, many of which end in little hooks (Figs. 18 and 19). These little hooks catch hold of the rolled edges of the opposite barbules, and thus the barbs are held together. By referring to Fig. 17 it will be seen that in this way each of the hook-bearing barbules catches hold of several of those opposite, and that each barbule of the row which has no

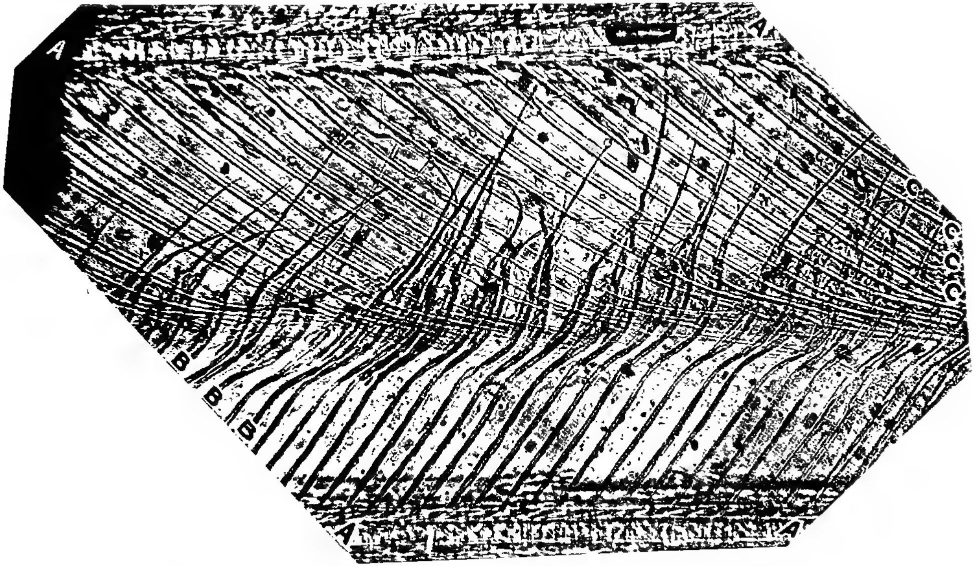

FIG. 18.—PART OF A PIGEON'S WING FEATHER HIGHLY MAGNIFIED.

A A Barbs. B B Barbules furnished with barbicels and hooklets.
C C Barbules without barbicels.

barbicels is caught by the hooks of several of the opposite set. Thus the hooks, although small, grapple the barbules in such a way that they are thoroughly efficient. As each barbule which bears barbicels has quite a crowd of them, and as there may be over a million of barbules on the feather, half of which will be provided with barbicels, the multitude of barbicels and of hooks may be imagined. It is not easy to give a definite estimate of what their number might be, as it is difficult to count these very small objects in the field of a microscope.

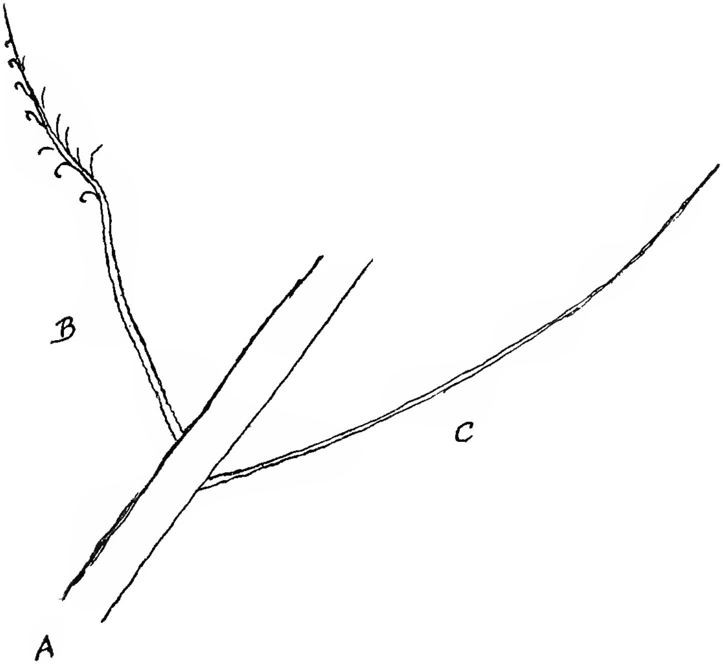

FIG. 19.—Diagram explanatory of view of part of pigeon's feather.

A Barb. B Barbule on side of barb farthest from base of feather furnished with barbicels, some of which have hooklets and some have none. C Barbule on side of barb nearest base of feather, not having barbicels.

If anyone should chance to enquire with what object these minute details of the structure of a feather have been given, the answer is easy. Not only may we point out that a minute description of any animal structure has a special value and a particular interest in many ways exceeding the value and interest of general descriptions and wide views, but such a description has a close bearing on our argument. For it shows that any tenable theory of evolution must account for the appearance of many millions of little barbicels and hooks, together with the turned-over edges of the opposite barbules of which they take hold. Now, when we say that evolution was guided by conscious prevision of the structure to be evolved, which was designed before it was formed, we have accounted for all this in a simple and reasonable way. It is not easy to understand how any other theory of evolution can be even supposed to account for it. But theories of evolution flourish as general views and get into difficulties when applied to details.

The feathers become a wing by being held in position by the bones of the fore-limb (Fig. 20). The skeletons of the higher animals are all constructed on the same plan, but variously modified to meet the requirements of each particular species. The more closely two kinds of animal are related the more easily can their skeletons be compared and matched with each other, bone answering to bone so closely, if they are very nearly related, that the correspondence is easily seen by anyone. But often when the relationship is not very close or the habits of the species compared are very different it is found that some bones have been lost and others have grown together in one of the species, so that the correspondence can only be made out by a careful anatomist. Now the wing of a bird corresponds to the fore-limb or arm of a mammalian, and on the whole, notwithstanding distance in relationship and difference of habits, the correspondence of the bones may be noted without much difficulty. The first bone in the arm, that

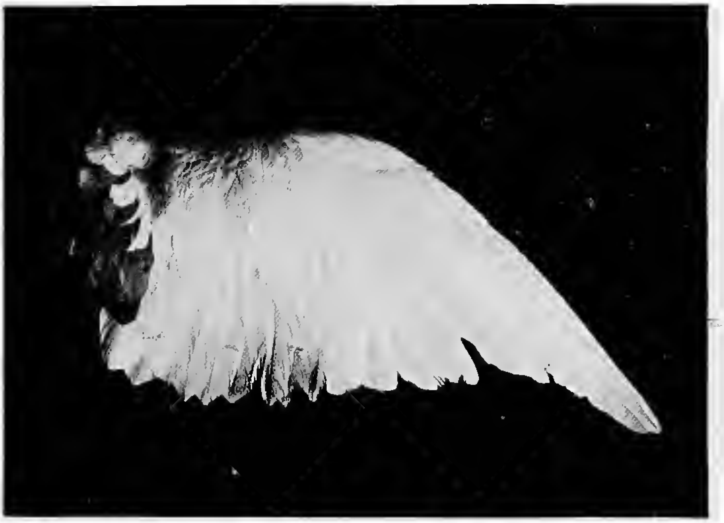

FIG. 20.—A PIGEON'S WING.

which reaches from the shoulder to the elbow, is called the humerus, and this may be easily seen to correspond with the first bone in the bird's wing. Next between the elbow and the wrist come two bones, the radius, which is fastened to the humerus so as to make a good hinge joint, but more loosely connected at the wrist, and the ulna, which is more loosely connected at the elbow and more closely at the wrist. This manner of connection gives the hand great freedom in turning round, but its working depends to some extent on the number of small bones which form the wrist joint. The radius and the ulna occur in the wing, but as the wing needs steadiness rather than free motion in its parts the bones in the wrist are greatly reduced in number, and most of those which correspond to the palm of the hand and the fingers have grown together, so that on the whole we may take the upper arm, the forearm, and the hand as three sections of the frame on which the wing is spread, having one upper and two intermediate joints by which it may be moved and folded.

The most effective feathers in flight are those on the hand, which, of course, move more quickly than any others when the wing is used, and these are called primaries. Next come those on the forearm, which are all carried by the ulna. They are called secondaries. The tertiaries, which are found on the upper arm or humerus, can do but little to add to the effect of the others in the beat of the wing, but may be quite efficient in soaring or gliding.

The wing feathers are so shaped and arranged that the whole wing has a curve. The lower surface is like the hollow or inner part of a saucer, while the upper surface is like the outer curve of the same saucer. Thus in the downward part of the beat the wing catches the air and holds it, while the curve of the upper surface passes upwards in the return with less resistance. The feathers are also placed with the wider and more flexible side of the vane partly under the narrower and stiffer edge of the next feather, so that it may be held stiffly against the air when the wing moves down, but may yield a little and let it pass when moving up. It is said also that the barrel of the feather turns a little at the place where it is attached to the wing, so that the whole feather moves and opens the way a little more widely.

At the forward edge of the wing sets of small covering feathers are found above and below. These make the part where they grow quite impervious to the air, and this is of great importance to the bird, as the strip of the wing close to the front edge is the part chiefly concerned in soaring and gliding.

The bird's flight may be best considered under its three common forms, gliding, flying, and soaring.[1]

In gliding the wings are extended and motionless, and the bird, impelled by motion derived from previous flight or from descent from a higher to a lower level, advances a considerable distance without any exertion. The support given by the air to a body gliding is much greater than what it gives to a body falling perpendicularly, and this is a fact of great importance, as it makes the glide much longer than it would otherwise have been. The reason of it is this. When a body falls perpendicularly it experiences some resistance from the inertia of the particles of air in its way. But as it falls it carries them with it, and so most of the particles with which it is in contact after the first moment are those whose inertia has been partly overcome and which are beginning to fall with it. Their resistance, it is evident, cannot be as great as the resistance of fresh particles whose inertia is intact. But when the body is moving forward rapidly fresh particles are constantly encountered, and those which have given support are left behind, so that the upward pressure of the air is much greater. As the fresh particles are found coming in at the forward edge of the wing and the used particles going out at the back it is evident that the greater part of the support will be received by a narrow strip near the front edge. Hence to lengthen the wing would add greatly to its supporting power, but to widen it would have little effect. The experiments which have led up to the present development of the aeroplane began by a long series of glides from the tops of hills to the valleys below, and hence this method of progression through the air has been very carefully studied. In accordance with the principle which has been just explained it was found in the course of these experiments that the proper form of plane to be used for the support of a flying machine was narrow in the direction of flight, but of considerable length at right angles to it. It may be worth noting that in the early times of the aeroplane when its real form was not well known the pictures and sketches which were made to represent it generally showed the supporting plane moving with its greatest length extending from front to rear, showing that the actual shape is not what would have been chosen before trial was made.

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[1] For a fuller discussion of a bird's flight, see Newton's *Dictionary of Birds*, p. 260.

In gliding, birds can direct their course either up or down and to right or left. The fact that the front edge of a gliding plane is most efficiently supported by the air gives it a tendency to turn upwards, and the more quickly the plane moves the greater is this upward thrust. This may be seen by throwing a card so that it lies horizontally as it moves. It will be found to have a decided tendency to move in an upward curve. The bird can overcome this tendency by stretching its head forward so as to alter its centre of gravity, by spreading its tail out so that the lifting part of the supporting surface may be a smaller proportion of the whole, or by bending back the hand part of the wing, that is its outward or last part, so that the advancing edge may be made shorter. It may also turn its tail up or turn it down, when it will act upon the air and change the direction in which the bird moves.

When the bird changes its direction to right or left it does so by leaning over to one side. When its right side is depressed it turns to the right, and when its left side is depressed it turns to the left. It does not steer like a ship with a rudder. If its tail were to be used as a rudder it would have its thin end vertical, so that it might act on the air with its flat side for that purpose. A vertical plane is used on aeroplanes in this way. The bird may lean over to one side by putting its head over to that side, or it may slightly draw in the wing on that side, or it may turn the half of its tail which lies to that side up and the other half down. This last movement must be very easy for those birds whose tail is divided into two distinct portions. But however produced, the turning movement consists simply in leaning over to one side. It is worthy of note that all these movements are very simple and easy and require very little muscular exertion.

In flying by beats of the wings the support given by the air acts in the same way as in gliding, being most felt at the front edge of the wing, and always increasing with the speed. When the bird is actually in motion the wing in its downward beat moves forward as well as downward. It therefore meets continually with fresh particles of air whose inertia has not been acted on, and its stroke is consequently much more effective than a similar stroke made when the bird is just starting or flying slowly. The result is that the first start is the great difficulty in flying, and requires much greater exertion than the subsequent course. Fig. 21 represents pigeons flying, as they appear when just setting out. They are using their wings very vigorously, swinging them up and down as far as they will go. All the attitudes shown in the figure may easily be seen by watching a flock of pigeons taking flight from the roof of a house. If they are not startled and trying to get up full speed the motion of their wings may be easily followed by the eye, and now and then the wings will be heard to strike together as they meet

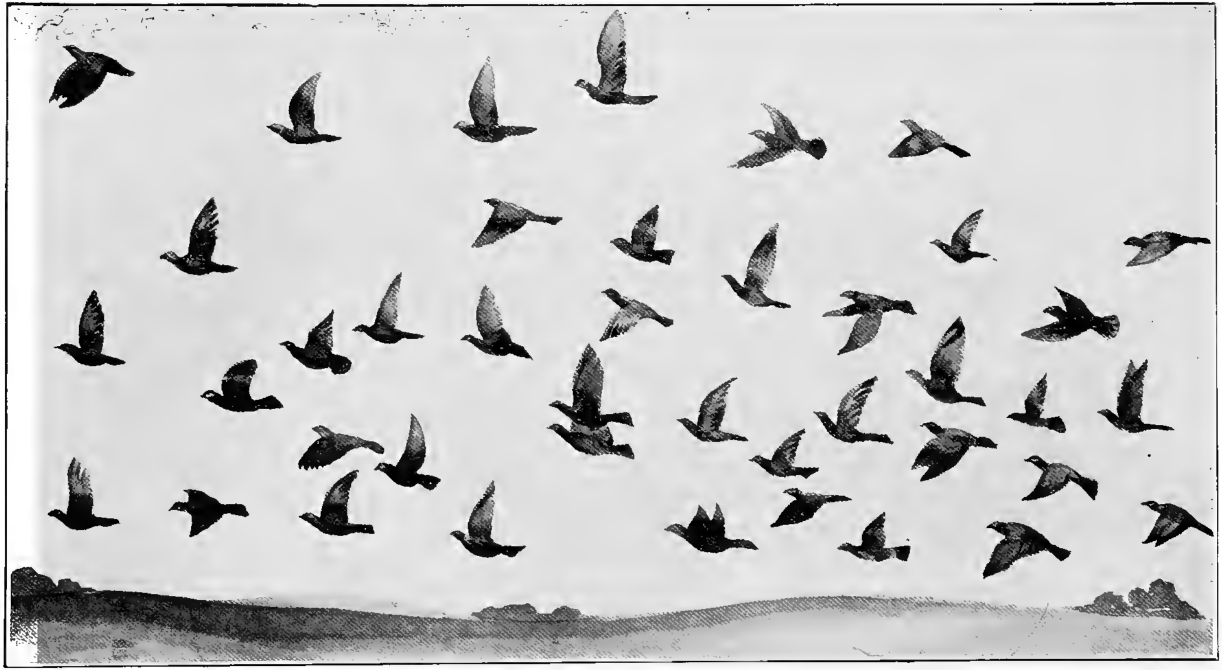

FIG. 21.—PIGEONS FLYING.

above. But afterwards they will be seen flying with less exertion and not so wide a sweep of wing. Birds with long wings and short legs often have considerable difficulty in rising from the ground or the sea. The albatross is a splendid flyer, but it may be seen on land helping itself by a run or by taking advantage of rising ground, and on sea it will be found to start from the top of a wave and to beat the water with its wings at first setting out. Many aquatic birds may be noticed beating the water for a good many strokes while getting up speed, and it will be observed that all birds are apt to rise into the air facing the wind. A bird that flies from a branch may start more easily by letting itself drop a little at first, thus gaining in speed what it loses in height, and birds will often be seen to start in this way when undisturbed, but if they are frightened or otherwise excited they use greater exertion and begin to rise at once. That the exertion required at first setting out is very great has been proved by experiments on pigeons. These birds can easily fly for hours at a time without being tired, and yet when made to rise from the ground and fly five or six times in quick succession they will refuse to rise again and remain on the ground panting with open beak.[1]

A bird's wings do not move up and down in a straight line. They are so moved that the end of the humerus, that is the bone nearest the shoulder, moves in an ellipse, and the wing turns a little. Thus the under surface is turned somewhat backward during the downward stroke, while it is the upper side which looks back when the wing is moving up.

In what has been written there is given merely an outline or sketch of what is known about the ordinary flight of birds. It will be found, however, quite enough to open the eyes of anyone who cares to observe for himself. By keeping it in mind and noting what he sees as he walks along the streets or roads, he will soon come to understand a great deal about the ways of birds, and more especially, he will be able to account for all their various movements and attitudes in flying, as those which have been described here will enable him to understand all the rest. He will also see how the shape of a bird's wing and its way of using it have a certain relation to the ordinary circumstances of its life. For instance, it is evident that a comparatively broad wing quickly fluttered will raise a bird most easily from the ground and enable it to start off almost at once at its full speed, but such a wing would never attain to any great speed, nor would its possessor be able to take very long flights. But a long narrow wing which could not be fluttered in the same quick way would be the wing for speed and endurance, while at the same time it might give more trouble at starting and getting under way. And it will be found that the birds which frequent woods and thickets, and which are always taking short flights and stopping and starting again, have short, broad wings which they move in a quick, fluttering way, while the birds which fly far and remain for a long time together in the air have long and narrow wings and take a more sweeping stroke.

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[1] Newton's *Dictionary of Birds*, p. 267.

The greatest difficulty in the whole question of birds' flight is to account for what is called soaring or sailing. This is possible only for those birds which have the greatest powers of flight, and for them only when the wind blows with a certain force. No bird can soar in a calm. In soaring the bird moves in circles, at the same time rising and falling as it passes round the circle, making its course a sort of spiral. Its wings are fully extended and held out without any apparent motion, nor can the bird be observed to put forth any exertion, and yet it can thus rise high in the air and make its way far to windward of its original position. Eagles, Vultures, and Adjutants are the chief of the soaring birds, and they have often been seen in this way to attain a height of several miles above the point from which they started.

The soaring bird begins at some height above the ground or sea by moving in curves or circles, and therefore of necessity up and down the wind alternately. When sailing down the wind it falls, and when moving up against the wind it rises, the result being to bring it far above its original position, and sometimes far to windward. It is very hard to see where the force comes from by which the soaring bird rises. If we could suppose that there were upward currents of air of which it took advantage the thing would be simple enough, and such currents no doubt do exist where the wind blows against the face of a cliff or the side of a hill. But there is no reason to suppose that any sensible upward current can be found at the great heights to which soaring birds attain. They must therefore be able to do without this assistance. It has been suggested that the wind blows with less force at the surface, being retarded by friction with the ground, and moves more and more quickly as greater height is attained, and that the bird in some way takes advantage of this. But if this is the explanation there must be so much difference between the speed of the wind at the higher and lower parts of each circle made that a heavy bird can rise by means of it, and as the bird makes many circles in attaining its highest point, the speed of the wind there must be something amazing. But it has never been asserted that when the wind blows moderately on the top of a high mountain a soaring bird is unable to rise from the adjacent plain. Moreover, if a bird could gain more force by dropping down a certain height than it lost by rising through the same height, and could gain more by going a certain distance with the wind than it lost by returning against the same wind, it would really prove itself to be able by skilful manipulation to make something out of nothing, and would justify the action of those who in former days spent so much time and energy in trying to discover perpetual motion. If we could suppose that the wind blew in puffs moving alternately faster and slower, we could understand how by going down on the puff and returning on the pause it might be possible for the soaring bird to rise. Or it may be that there is some peculiarity not yet noticed in the way the wind blows of which advantage is taken. Perhaps when the aeroplane is so much improved that the airman can attend to other things besides keeping his balance we may come to understand better the conditions which prevail in the air, and then it may be easier to explain how a bird soars.

Whatever the explanation may be, one thing is evident. There is more to be explained in flying than the structure of the wing. The possession of a fiddle does not make a fiddler, and the possession of wings would not teach a bird how to use them. Besides its wings the bird must have an instinctive skill, and in some cases a very considerable skill, if it is to make any effectual use of them. But no bird has so much intelligence as would enable it even to think of any new art, much less could it be expected to master it. It remains, therefore, for those who will not believe that conscious prevision was exercised in directing the course of evolution to explain not merely the evolution of the wing, but, what is still harder to account for, the evolution of the capacity to use the wing.

We have already sufficiently remarked in the course of this exposition on the difficulty or rather impossibility of ascribing the evolution of so complicated an organ to anything acting on it out of the past, and not directed or controlled by conscious intelligence looking to the future. The forces that have been collected and ordered in the past can only hand on to the future the order that is already in them. They cannot add to it anything that is new. If this has been evident in the case of simpler combinations and contrivances it must appear much more evident in the case of so elaborate a contrivance as a bird's wing, consisting as it does of millions of separate parts, all of which must work together to produce the required result. It is not, as we have frequently remarked, in reality at all more impossible in the case of an elaborate contrivance than a simple one. There are actually no degrees in impossibility. But the case of an elaborate contrivance is more impressive and striking and more likely to be perceived, as an argument which makes no impression when whispered may be attended to when it is shouted.

Having such an arrangement before us, we may very well pause a moment to consider how it is affected by the theory which M. Bergson has recently enounced. This theory is supposed to be more successful than others in accounting for the progress of evolution without assuming the exercise of conscious prevision. Bergson takes evolution to be the work of life and ascribes its advance to the energy, spontaneity or, as he calls it, the *élan* of life. Now life is supposed to be more than life as we generally understand it, that is to say, than the characteristics common to living things. It is said to be something more than an abstraction. What more it is we can hardly enquire without undertaking a criticism of Bergson's philosophy, nor may we stay to ask what evidence there is that any such thing exists. We are only concerned with the kind of action which is attributed to it. If it were supposed to have consciousness and to exercise foresight and design there would be nothing in the theory to contradict any of our conclusions, but inasmuch as its action is always spoken of as if it were a blind unconscious striving or effort to realise itself without any determined aim we have to bring to a focus again the conclusions at which we have so often already arrived.

We have to point out that whatever may be the force behind evolution it has in the bird's wing assembled a great number of separate parts and portions of matter, and has disposed them in a new kind of order and arrangement not contained in or implied by any order or arrangement that existed before. In this arrangement one part is disposed with regard to another, and all are so co-ordinated as to make an instrument exactly suited to perform a certain action. And we have also to point out that our deepest and most certain intuitions of the nature of matter make it impossible to suppose or imagine that any material bodies or particles can ever arrange themselves in any regular or orderly way without the guidance of conscious intelligence, while our deepest and most certain intuitions of consciousness and intelligence leave us incapable of supposing that it can bring orderly arrangements about in any other way than by foreseeing them and seeking to establish them or, in other words, by making a design and carrying it out. Blind unconscious or undesigning life may impart force but cannot impart arrangement. It may move itself about but it cannot realise itself.

Bergson puts the same theory in other words when he says that the action produces the organ, vision produces the eye, and flying produces the wing. Now it is not easy to understand what flying is if it is not the action of using the wing. It would be more intelligible if we were told that the wing produced flying. If we have to suppose any kind of flying that could exist before the wing or come into action simultaneously with the wing it must be a desire or wish to fly, or an imagination and effort to bring about the action of flight. But any such wish, imagination or effort would imply the conscious prevision of flight and the attempt to carry out a design. We see also that the wing is now formed in the shell before there could be any possibility of flight, and so far as we can trace the cause of evolution it must have been so formed from the first and every addition to its organisation must have been thus added to it from time to time before it could be used. The only possible order in which we can arrange the circumstances relating to this organ is: the design of the wing first, the production of the wing next, the use of the wing last.

CHAPTER XIX

THE PECTEN'S EYE

OUR desire to make trial and application of our argument has led us through many tracts of Nature and brought many organisms under our notice. Of these we have not made choice according to any rule or plan, but have taken up anything impressive or interesting that presented itself; acting like a naturalist taking a country walk, who does not keep to the beaten path but is drawn aside now by a flower and again by a bird's song. And now it is our fortune to light upon an object which has a double interest for us, being not only in itself most suitable to illustrate our argument but also the example which M. Henri Bergson has chosen to illustrate his theory of evolution.

The Pecten is one of the tribe of Molluscs, a group of living organisms of very great antiquity and very widely distributed. As to its distribution, so wide is it that there are three classes in the tribe which have become universally known and which are constantly met with. These are the Gasteropoda, such as the snail, the periwinkle and other animals having univalve shells; the Lamellibranchia, such as the oyster, the mussel and other bivalves, and the Cephalopoda, which include the nautilus and the cuttle-fish. The antiquity of the tribe is so great that no fossils can be found to show how or when the classes into which it is divided parted from the parent stem, or to tell us what was the form of the original mollusc and which were the nearest relatives from which it had most recently become distinguishable. We are entitled, therefore, to say that the existing species of Molluscs are very remotely akin to the existing species of any other natural tribe, and that their common ancestor must have flourished an amazingly long time ago, and must have been a very simple animal, presenting very few of the peculiarities by which his descendants are now distinguished. If, therefore, we find in a mollusc and in one of another tribe, say a vertebrate, a very complex organ, having generally the same plan, we are entitled to say that it did not appear in their common ancestor, but was independently produced in each tribe. Now M. Bergson thinks that by taking such an organ as an example and asking how far various theories can account for it he will most easily clear all other theories out of the way and advance his own, and this gives the example that he has chosen a special interest for us. That example is the Pecten's Eye as compared with the eye of a vertebrate.

The Pecten is a Lamellibranchiate or bivalve which is found in many places and very abundantly in the waters round our own coasts. It is obtained by dredging and is much used by fishermen for bait, and is also sold in many fish markets, where it is generally called Scallop, Escallop, or Clam. It is the opinion of many naturalists and others that if it were better known it would be more highly appreciated as an article of diet. Some go so far as to prefer it even to the oyster, but these, surely, take an exaggerated view of its undoubtedly great merits.

The pecten either lies at the bottom of the sea or moves about by swimming. Its way of swimming is so peculiar as to be worth describing. We shall therefore ask the reader to note a few points in the animal's structure. It is covered and defended by two symmetrical but unequal shells. In *Pecten maximus*, perhaps the best-known species, the left shell or valve is flat, while the right shell, on which the animal rests, is convex; in *Pecten opercularis* both shells are convex, the left more so than the right, but it also rests with the left shell uppermost. The shells are joined together at the back by a strong hinge. They are everywhere lined by a fleshy substance, part of the pecten's body, by which the shell is in the first instance secreted; this is called the mantle. Along the edge of each shell a part of the mantle stands out at right angles to its surface in front and at the sides, but not reaching quite up to the hinge; this is called the veil. Therefore, when the valves are partly open the pecten is not exposed to view, but the upper and lower veils touch and form a sort of shutter all along the opening. Now, when the pecten wants to swim it opens its valves and takes a sort of bite of the water and then shuts them up quickly. The veil keeps the water from coming out in front and sends it out backwards in two streams on each side of the hinge at that part of the shell to which the veil does not extend, and so the animal moves forward. At the same time, if it is frightened, it is able to turn the veil in, send out the water in front and dart away backwards, that is with its hinge foremost. It is altogether quite a lively and active mollusc.

This is, no doubt, the reason why it is so well provided with eyes. Just inside the edge of each shell and between the shell and the veil stretches a band of tentacles amongst which are seen a number of small, glittering eyes. These vary in number, but are always more numerous on the side which the pecten keeps uppermost than on that on which it lies. They may amount in number to thirty, forty, or even fifty in a row. They do not turn from side to side but look out on what is before them and hence, no doubt, the pecten finds a great number useful, as with a few it would have a very confined and limited outlook. But what makes these eyes so interesting is that they are very complex and highly organised and that their plan is wonderfully similar to the plan of the vertebrate eye.

The eye is situated, as has been said, on the mantle between the edge of the shell and the veil. It is placed upon a short stalk (Fig. 22, *E.St.*) which does not appear to be movable. The skin of this stalk and of the sides of the eye is charged with a dark pigment which excludes the light, but from a small circular area at the top the pigment is entirely absent. This is the cornea (Fig. 22, *Cor.*) ; it is shaped like part of a sphere and is very transparent. Behind the cornea is the lens (Fig. 22, *L.*) ; it is a double convex, the lower side being very much more convex than the upper. The lens lies in a chamber which answers to the vitreous humour of the vertebrate eye and below it is found the retina (Fig. 22, *R.C.*, *R.*). Here we find the most remarkable resemblance to the vertebrate eye, for the retina shows two layers, one containing ganglions, *R.C.*, and one of rods, *R.*, and the layer of rods which is that sensitive to light is farthest from the lens, so that the rays pass through the retina which is transparent and are brought to a focus at the farthest end of the rods.

Behind the layer of rods, which is the sensitive or seeing part of the eye, we find a structure which is not at all represented in the vertebrate eye. This is a bright or reflecting layer, the Argentea (Fig. 22, *Arg.*). Dr. Dakin records[1] experiments which show that the lens and argentea act together as a true optic lens and mirror, and form an image just where the rods are placed to receive it. It is the light reflected from this layer which gives the pecten's eyes their bright and glittering appearance.

Behind the argentea we find a thick layer of pigment, the Tapetum (Fig. 22, *T.*), which will absorb any light that passes through the eye and so prevent confusion. Behind that again is a layer of tough, connective tissue, the sclerotic coat (Fig. 22, *Scl.*), which forms a firm basis for the retina.

The optic nerve on its passage to the eye divides into two branches. One of these, the inner optic nerve (Fig. 22, *Op.n.i.*), passes on to the back of the sclerotic coat, where it spreads out and goes up on all sides outside the containing

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[1] *L.M.B.C. Memoirs, XVII., Pecten,* p. 110.

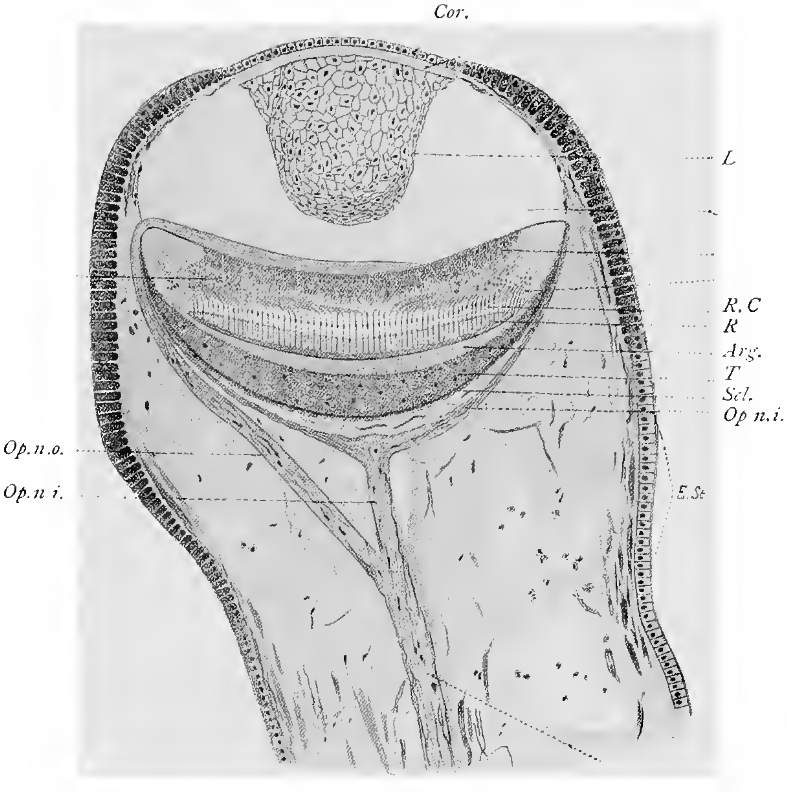

FIG. 22.—PECTEN'S EYE.

From *L.M.B.C Memoirs, XVII., The Pecten*, by W. J. Dakin.
By kind permission of the Liverpool Biological Society.

Cor. Cornea. *L* Lens. *R.C* Retinal cells with ganglions. *R* Rods. *Arg.* Argentea. *T* Tapetum. *Scl.* Sclerotica. *Op.n.* Optic nerve. *Op.n.i.* Inner optic nerve. *Op.n.o.* Outer optic nerve. *E.St.* Eye stalk.

membrane until it comes to the upper edge of the retina, where it passes in and makes its way to the rods. The other branch, the outer optic nerve (Fig. 22, *Op.n.o.*), goes up on the shell side as far as the upper part of the retina, where it enters and passes along the surface of the retina and becomes continuous with the nerve fibres of its outer layer.

It is impossible to contemplate such an organ as this without a feeling of awe and wonder at the lavish hand with which the most elaborate instruments and contrivances have been bestowed on one of the most humble of living creatures. The reader may have thought the description of the pecten's eye a long one, yet it does not contain one-tenth of the details that might be given of its marvellous and complex structure, and all this wealth of contrivance and construction goes to promote the welfare of a creature which may have no higher destiny than to become a star-fish's prey or a fisherman's bait.

The pecten's eye is not exactly the same as the vertebrate eye, but they have some very striking resemblances. There is the same arrangement of cornea, lens and retina, and there is the same peculiar inversion of the parts of the retina, by which the active or seeing part is farthest from the front of the eye. It is, in fact, an adaptation of the same plan to different circumstances, just what might be called, if it would not arouse controversy, not a servile copy, but an intelligent modification. It is this similarity of plan in the case of animals so remotely related that has led M. Bergson to take the pecten's eye compared with the eye of a vertebrate as his text. If it is thoroughly understood, as has been so often explained in the course of this argument, that every increase in complexity, every additional orderly arrangement, combined with what before existed must be due to deliberate intention and design, and can by no means be ascribed to chance, then either eye by itself is an instance of design so thoroughly satisfactory and conclusive that nothing is really gained by combining them. But if it is felt that there is a possibility, however faint, that order may arise by chance, then the comparison of these two instances adds so amazingly to the adverse combination of chances that the faint possibility altogether passes away. We are glad, therefore, to follow M. Bergson and add one argument to another. After that we shall see whether his own explanation will stand.

He begins by assuming the Darwinian theory of insensible variations and supposing the eye to be due to small differences arising by chance and continually accumulating. Now the point to be kept in mind is that all the parts of an organism are necessarily co-ordinated. The organ will be of no use, will give selection nothing to take hold of unless it works, and it will not work unless one part answers to another and makes a good fit. If the retina develops and becomes more complicated its development will hinder vision instead of favouring it if the visual centres do not develop at the same time as well as the several parts of the visual organ itself. But then "if the variations are accidental how can they ever agree to arise in every part of the organ at the same time so that the organ will continue to perform its function?" This question occurred to Darwin and caused him to suppose that the variations must be insensible. For a very slight difference in one part of an organ will not hinder its working and so it may wait until a complementary variation somewhere else comes in to make it positively useful. But here we note that if the small variation does no harm, neither is it of any use until the complementary variation comes in, and we ask, What is to keep it from passing away in the meantime? We must not suppose that it is retained because there is somewhere a feeling that it may be useful and yet we see no other way of providing for its permanence. But this thought, so little conformable to Darwinian principles, is absolutely forced upon us when we observe the likeness of structure of the vertebrate eye and of that of the mollusc. "How could the same small variations, incalculable in number, have ever occurred in the same order on two independent lines of evolution if they were purely accidental? And how could they have been preserved by selection and accumulated in both cases, the same in the same order, when each of them taken separately was of no use?"

Now let us turn to the alteration in the Darwinian hypothesis suggested by the observations of de Vries and see whether the supposition of sudden variations will help us. In one way it helps us considerably, for we have not so many steps to account for and we can more easily understand how each step might be preserved and added to the others, since we may suppose that each by itself is of some use and therefore supplies material for natural selection. But if we are carried past one difficulty we are set down before another just as great; how do all the parts of the eye after the sudden change continue to work together so well that it is still able to see? If one part were to change by itself vision would be impossible unless the change were absolutely infinitesimal. And so all must change together and must so change that the alteration in one part fits into and works with the alteration in every other part. The most sturdy advocate of the power of chance must surely feel his faith strained to breaking point by such a supposition. And yet having supposed it to occur and that after the elimination of millions of less fortunate individuals one survivor is found possessing an altered eye that works and is somewhat improved, this, after all, is but one step gained, and a similar chance must happen again and again in the history of a species, every time giving all at once new complications so marvellously regulated with regard to each other and so related to former complications as to go farther in the same direction. "How can we then suppose that by a series of mere 'accidents' these sudden variations occur—the same in the same order—involving in each case a perfect harmony of elements more and more numerous and complex—along two independent lines of evolution ? "[1]

The law of correlation may be invoked here. A change in one part brings with it of necessity a change in some other part : white cats with blue eyes are generally deaf ; hairless dogs have imperfect dentition, and other like cases. For an answer to this M. Bergson distinguishes two kinds of correlation : the one a system of *solidary* changes which all spring from one root, and the other a system of *complementary* changes so co-ordinated as to keep up and even improve the functioning of an organ under more complicated conditions. He notes that all the cases cited are cases of *solidary* changes ; hair and teeth, for instance, are homologous formations, and what injures one may well injure the other without requiring any special explanation. And he notes also that all the cases given are cases of loss and injury, diminutions and suppressions, not improvements and additions, which makes a very great difference. But a series of *complementary* changes would be a different thing altogether, for such changes are not bound together by any kind of necessary union. That by some disease or change in the germ the different parts of the eye should all decay together would be by no means marvellous, but that they should all improve together would be another kind of change and would be especially remarkable because the improvement in each must be fitted to and must answer the improvement in all the others. M. Bergson maintains that when correlation is appealed to as a support for the Darwinian hypothesis the word is applied ambiguously, so that the instances given are solidary changes, while the difficulties to be accounted for are complementary changes. Thus the Darwinian hypothesis fails as, if the variations are insensible, it does not explain how such as tend in the required direction are to be preserved and accumulated, while if they are sudden and considerable it is impossible to account for their correlation.

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[1] *Creative Evolution*, p. 70.

But some naturalists have supposed that these changes might be due to the direct action of the environment. We must see how this hypothesis works. The molluscs and the vertebrates whose eyes we have been considering have been equally exposed to the influence of light; they have yielded to that influence; light has so acted on them as to change their structure and to adapt it to itself, and from this arises the similarity of their eyes. They are the results of the same cause, the imprints of the same stamp. The organisms have merely become adapted to their surroundings.

Here, again, M. Bergson finds ambiguity in the reasoning. There are two kinds of adaptation, passive and active. Passive adaptation occurs when water placed in a vessel takes the shape of the vessel, when anything falls into the form given it by its surroundings; this is the kind of adaptation that may be compared to an imprint, but this will not explain the eye. Active adaptation reacts upon circumstances and responds to them; it furnishes answers to their problems and makes the best of them; it contains a great deal more than is in them and so rises superior to them. The photographic plate yields to the influence of light and so the photograph is explained, the photographic apparatus makes use of light and much more than light is necessary to explain it. The eye is like the photographic apparatus and, not like the photograph, it is adapted to light because it can make use of it; there is a great deal more in the structure of the eye than the properties of light can explain.

There is even more in the use that is made of light than is contained in the structure of the eye. For the eye is united to a nervous system, a muscular system, an osseous system in the case of vertebrate animals, and all these use and are guided by the light which falls on the eye; their movements and actions are part of the use that is made of it. We are not surely to say that light has built up all this apparatus, nor yet that organised matter has a capacity in itself for constructing new and complicated machines.

Here M. Bergson stops to consider the theory especially associated with the name of Eimer, that physics and chemistry give the key to everything, and that evolution is brought about by the influence of external causes acting continuously in the same direction. He has, indeed, already considered the same theory under the name of adaptation, but now it comes up in a slightly different form, or, at least, illustrated by other examples. He cites the cases of the different butterflies, *Vanessa levana* and *Vanessa prorsa*,[1] which had long been regarded as independent species but were at last found out to be the same, the difference between them arising from the climate in which they were bred, so that either of them removed into the other's territory had offspring of the local form. He also refers to the crustacean, *Artemia salina*, which assumes different forms according to the degree of saltness of the water in which it is bred, and in these cases he remarks that it looks as if the external conditions were the cause of the transformations, and physics and chemistry might give the key to everything.

M. Bergson meets this case in his favourite way by alleging an ambiguity in the word cause. He shows that it may have three different meanings which might be confused in treating of the cases mentioned. A cause may act by *impelling*, as when one billiard ball strikes another and sets it in motion; it may act by *releasing*, like the spark that explodes the powder, and it may act by *unwinding*, like the spring which causes the gramophone to speak. Now it is only in the first case that the cause contains the effect or passes into it and explains it. In the second case the quantity and quality of the cause are in no way represented in the effect, and in the third case only its quantity and not at all its quality. But in all the cases cited to prove that outward circumstances can cause physical changes the cause is evidently of the second or third sort and not of the first. The effect was really there already and all that the cause did was to bring it out.

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[1] *Creative Evolution*, p. 76.

M. Bergson labours this point at some length, but we need not dwell on it here much longer. It is only what has been urged so often already in the course of our argument. We must distinguish between the bringing in of something new and the bringing to light or displaying of what is already included in the plan of the organism. Every theory which has sought to account for the progress of evolution has been built up by instances of this latter sort. Each of them dwells upon some one means by which the variety concealed in the plan of an organism may become manifest. Use and custom, chance and external conditions, are all appealed to with success. But the changes are all on the same plane, there is no advance to anything higher. We go from *Vanessa levana* to *Vanessa prorsa* and back again to *Vanessa levana.* We ring the changes upon twenty forms of evening primrose. But we never get to anything really new, to anything higher or more complex. The gramophone grinds out its accustomed tunes, but we never can put in a new piece. The gunpowder explodes; all that is easy, but we cannot find a change of the third sort; we cannot bring another ball to bear on the billiard ball and give it a new motion.

There remains yet another theory which would attempt to account for the evolution of such an organ as the pecten's eye—that which is known as neo-Lamarckism. This theory, like the original Lamarckian doctrine, supposes that variation arises through the action of the living being, which uses or neglects to use its various organs, but it lays stress on the consciousness and will of the animal which is supposed to be making an effort to adapt itself to its circumstances. M. Bergson here remarks that while we all admit that the exercise of an organ may cause it to increase in size and strength we cannot suppose that any exercise or any effort put forth by the animal can cause the slightest increase in the complexity of an organ. No instance can be brought forward in which anything resembling this has occurred, and yet if we compare the eye of the pecten with the simplest form of eye to be found, say the pigment spot of an infusorian, we shall see that there lies an immense number of steps between them, each involving a very great increase in complexity. Finally M. Bergson asks, even if this theory is accepted for animals, what about plants? And if we cannot apply the theory to plants, of what use is it as an explanation of evolution?

M. Bergson goes on to discuss the heritability of acquired variations, but if variations of a kind that would affect our argument cannot be acquired in any of the ways which have been alleged it is needless to consider whether such variations as can be acquired may be handed down to posterity. We may therefore pass on to his exposition of his own theory of evolution.

We have noted with high approval the method M. Bergson adopts in dealing with rival theories. He is fully persuaded that the duty of an explanation is to explain and that it must do this by being more simple and intelligible than what is to be accounted for. He has rejected every explanation that explains nothing and every explanation that cannot be thought out and understood. But he somehow fails to apply the same tests to his own theory; he treats it more gently and does not expect so much of it, and so he fails to perceive that if it is treated like the others it will be carted away in the same load.

We need not here go over the ground traversed in Chapter VIII, we are not now concerned with the question of the credibility of M. Bergson's theories. All that we have to do is to ask whether they explain the pecten's eye, that is to say, whether they give us an easier and more satisfactory way of thinking about it. Let us then first take up

M. Bergson's idea that life is not an abstraction. This means that life is not known to us merely as found in living things as weight is known as a property of heavy things, but that it has an independent existence of some kind. It must, then, be a sort of substance, portions of which are put into living bodies to organise the inert matter of which they consist. We may regard it as a current taking its rise at certain points of space and traversing the bodies it has organised.[1] Now how does this help us to think of the pecten's eye? What we want to understand is the organisation and co-ordination of the parts of this complex organ, and we are offered the idea of a current taking its rise somewhere during a very remote Geological epoch and passing on from generation to generation down to the present time. We have to think of this current spreading out and losing a great part of its force in every generation, and yet having apparently as great vigour now as ever. For, of course, the life which any living being has is lost when it dies and the life which it passes on, it passes on equally to all the eggs or seeds or germs which proceed from it. And of these only a small portion succeed in passing anything on to the next generation. Consider the millions of eggs produced by a cod-fish, each of them equally endued with this current of life and each of them equally able to pass it on to an indefinite number of generations, and add that so few are able to survive that the number of cod-fish does not increase, and then try to judge what fraction of the current of life is lost and what is passed on in each generation. Now we have to regard the fragment which has been passed on as accounting for the pecten's eye, and either in some way to account for or else to try to forget the vast bulk or intense compression of life at the beginning, or, if we can, we may ascribe to life some property which may make it intelligible that so much should be lost on the way and yet that so much should remain. And then we have to see how it helps us to understand the co-ordination of parts in the pecten's eye, to be told that it is due to an influence passing down from a very remote period. If we are to think of this influence as blind and unconscious, what is it but chance? and chance working from a great distance is not less but more uncertain than chance working close at hand. But if it is not blind, how does it differ from the conscious purpose so often alleged in the course of our argument as the only cause of order and organisation?

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[1] *Creative Evolution*, p. 27.

The idea of a current does not all fulfil the duty of an explanation, but we find that we may take it that life is a fluid—a beneficent fluid whence we draw the very force to labour and to live.[1] This delivers us from the difficulty of finding some way of accounting for the persistence of life, notwithstanding the loss which occurs in every generation. Life is no longer a current received in its entirety by each generation from its predecessor, but each generation finds itself in possession of what will serve its immediate needs and picks up more as it goes along. Life which animates our bodies now resembles the matter of which they are composed and its presence and succession may be thought of in the same way. But now we are left to puzzle ourselves over the problem of this supply of life. How do we draw the force to labour and to live from this beneficent fluid? Do we eat it with our food or breathe it with our breath, or how do we get our supply of it? We live on things that are dead, but surely we cannot extract life from them? This explanation only substitutes one difficulty for another. And, then, if we pass this over, how does it help us where we most need help? We are trying to account for the order and especially the co-ordination of parts in the pecten's eye and we find that we may refer it to a beneficent fluid. But may we say that this beneficent fluid knows what it is doing and acts with purpose? For if it does not its guidance, after all, is blind and it is incapable of producing any co-ordination of parts. But M. Bergson will not attribute consciousness or purpose to this fluid, and so once again we have been at the trouble of forming a complex idea only to find that it is incapable of explaining anything.

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[1] *Creative Evolution*, p. 202.

But we find M. Bergson in his liberal way giving us another idea to help us to explain the course of evolution, that of an *original impetus* of life passing from one generation of germs to the following generation of germs through the developed organisms which bridge the interval between the generations.[1] This impetus begins a long way off with the first organisms which began to evolve but retains its force up to the present and is capable of accounting for the co-ordination of parts in a pecten's eye. Oh, that M. Bergson had expended on this word "impetus" the same care that he bestowed on the word "cause" and expounded it with the same acuteness! We should then have learned that there may be a mechanical impetus, able to send the particles of matter hither and thither according to its direction and its force, and he would have shown how this kind of impulse is incapable of accounting for evolution, for he has his reasons for rejecting the mechanical explanation of nature.[2] Without entering into his philosophy we simply ask how does it help us? The effect of a mechanical impetus depends on its force and direction, and if we are to assume that the parts of the pecten's eye are brought together by a mechanical impetus we have to ask what accounts for the co-ordination between the mechanical impulses given to the separate parts which brought them together so accurately and adjusted them so precisely to one another? The mechanical theory only puts our difficulty one step back, and if we are to suppose that the effective impulse was given so far back as the first beginnings of life upon earth we shall find it impossible to imagine how

[1] *Creative Evolution*, p. 92.

[2] *Ibid.*, pp. 32–41.

that impulse could give rise to a co-ordination of parts at the present day.

The analysis of the idea of an impulse would, of course, have shown us that there may be other kinds of impulse not mechanical, there may be mental and moral impulses, and if anything of this kind were meant it might help us to understand the course of evolution. But this would bring in purpose and design, and that M. Bergson will not allow.

And then we would, no doubt, find that there was a third sort of impetus, namely, vital impetus, and that this was what was meant. But what sort of impetus can this be? We can easily understand an impetus which acts mechanically, and that such an impetus might pass on whatever form of organisation it had received. We can even understand such an impetus, acting after the same mechanical fashion, and dealing with nerve force and reflex actions. But we know of nothing which can increase the complexity of an organism but purpose and design. Then what can this vital impetus be? We have nothing that falls between an organism passing on the degree of organisation which it actually contains and a conscious intelligence working out a plan. We can, indeed, give a history of what has happened, but this is no explanation, and an explanation is what we want. There is nothing in this idea of a primitive impetus which makes it easier for us to understand the formation and co-ordination of the various parts in a pecten's eye.

Although we have failed up to this to find anything that explains the structure of the eye, everything that we have tried having the same defects that M. Bergson finds in Darwinism or neo-Lamarckism, we are not yet at the end of this wonderful man's resources. He offers us another way of looking at the matter, which may or may not be consistent with those that have gone before. So the eye, with its marvellous complexity of structure, may be only the simple act of vision divided *for us* into a mosaic of cells whose order seems marvellous to us because we have conceived the whole as an assemblage.[1] Here we find a certain emphasis laid upon the assertion that the act of vision is simple, and when the subject is referred to again the adjective simple is never omitted. The idea seems to be a simple act dividing into a complex structure. But it is impossible to see why the act of vision is called simple, one would think it ought rather to be called complex. For vision is the act of a complex organ and every part of the organ is kept at work while vision lasts. Now what can constitute a complex act except that it is a union or combination of a number of separate acts, all of which go on together and combine for one result. And that is precisely what vision is. Can it be that M. Bergson has confused simplicity with unity? Although the act of vision is complex it has unity. All the particular acts or movements work together for a common end. M. Bergson is very fond of accusing other people of confusing two ideas. He does not hesitate to launch this accusation against great philosophers and eminent naturalists. He appears to have in this instance himself confused unity with simplicity. This is even more apparent when he uses another illustration and speaks of a picture as a simple act projected on the canvas.[2] Now the action of painting a picture is as complex as any act can be. It consists of a vast number of movements of the artist's hands and may be continued day after day for months and even years. It is only because all these acts and motions are ideally united by depending on one purpose or tending to one end that they can be even thought or spoken of as one, and if M. Bergson calls this a simple act it is evident that the quality of simplicity has some extraordinary value for him and must be found at all costs.

But now we must try to use this idea of the simple act of seeing to explain the pecten's eye. The picture (regarded as a simple act projected on the canvas) may be represented in mosaic work by a collection of coloured squares, and you could imagine people who saw everything in squares like mosaic, and therefore the eye with its marvellous complexity of structure may be only the simple act of vision divided *for us* into a mosaic of cells whose order seems marvellous to us because we have conceived the whole as an assemblage.

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[1] *Creative Evolution*, p. 95.

[2] *Ibid.*, p. 95.

This seems to mean that just as a mosaic worker would divide the picture (which is the act of painting) into squares so do we divide the eye (which is the act of seeing) into cells. The cells, then, are only conventional representations, like the mosaic worker's squares. But are the parts of the eye only conventional representations ? Do the cornea, the lens and the retina answer to the mosaic worker's squares ? Have they no real existence ? Moreover, the mosaic worker does not find squares in the act of painting, which consists in the motions of the artist's arm and fingers, but in the result which is the picture, and we are not asked to make a division in the result or the act, but in the instrument which differs from both. It is very hard to understand how the act of vision can be divided into the parts of the eye and the comparison with a picture does not make it easier.

We are given another comparison to help us to use this explanation. We must try how it works. " When I raise my hand from A to B I feel that I am performing a simple indivisible act, but perceived from without it is the course of a certain curve A B. In this curve I can distinguish as many positions as I please and they have sprung automatically from the indivisible act by which my hand has gone from A to B." The way in which the comparison helps us is this : for the simple and indivisible act of raising my arm we are to substitute the path travelled over by my arm, and then regarding this path as divided into an indefinite number of points we are to understand that as the simple act of raising my arm sheds this row of points so the simple act of vision divides into the multitude of parts of which the eye is composed.

Here, again, the comparison rather hinders than helps. For the hand and arm make up the organ by which the act of motion is performed, just as the eye is the organ of vision, and we divide the eye into cornea, lens and other parts, just as we divide the arm into nerves, muscles, bones and so forth. What parallel can we find between dividing the path of the hand into points and dividing the act of vision into the parts of the eye? And how are we to suppose that this latter division comes about?

There is yet another way of taking this idea. We may regard the hand and arm as thrust into a mass of iron filings, which yield to it but retard its course. Now when its impetus is exhausted and it comes to rest, the iron filings fall into shape around it, and the farther it has gone in the more of its shape will it impose upon them. Thus, we may take it, the simple act of vision, according to its greater or less degree of penetration, forms a more complex or a simpler eye. But in this case the act consists in forcing a mould or shape on the iron filings, and our interest is concentrated on the mould and we want to know how it was shaped. If we are to conceive the formation of the eye after this fashion we must look on it as formed by a mould pressed on it from the outside. It is, however, quite evident that the eye was not formed in this way. Eyes grow, they are not moulded, and no comparison based on any process of moulding or stamping will help us to understand the eye.

It would be interesting to know who it is that exercises this simple act of vision that divides into the parts of the eye. It cannot be the pecten, because its act of vision is not exercised until the eye has been formed, and it is quite evident that the pecten's act of vision has no effect upon the structure of the eye. Moreover, it is called Nature's simple act of vision, and Nature must be regarded as something more than a simple pecten. May it not be that as the actions of the artist who paints the picture, continued as they are from day, are taken together and regarded as the simple act of painting the picture, so all the acts of seeing performed through all kinds of eyes from the beginning of evolution may be taken together and regarded as Nature's simple act of vision? There would be an almost sublime audacity in presenting this as a simple act, and yet it is probably what is meant. It is a sort of mystical view of evolution, but it is open to the same objections that have been already considered. If in any one case the eye is the organ and vision its function the combination of an unlimited number of such cases will not make the eye into a product of the act of vision. Nor do we gain anything by substituting for all the beings endued with eyesight a mythological being called Nature to whom their acts of seeing may be ascribed.

All that can be made out of M. Bergson's theories when they are all combined together is that the whole course of evolution is to be ascribed to some mysterious original impetus which, when it had once come in, passed on from generation to generation, always compelling the organism to pass into a state of higher development and greater complexity. Now it does not help us at all to understand the course of evolution that we are told to ascribe it to an unknown force acting in a mysterious way. To accept such an explanation differs little from saying that we know nothing about it. And it leaves us with a difficulty on hand which it has itself created. For in so far as it is a force or impetus we expect it to act everywhere. And when we find cases of degeneration, cases in which a complex organisation slowly acquired by the species is altogether dropped, we ask how has the original impetus affected these cases? If it has passed into them why did they not yield to it, and if it has passed by them how have they been missed? Our efforts to use M. Bergson's ideas as an explanation of the construction of the pecten's eye have had no other result than to create this difficulty from which the other hypotheses that have been passed in review are free.

We might be disposed to assume now that all other ways of explaining the course of evolution had been dismissed and the door was left open for our own were it not that we understand M. Bergson to have a special objection to it. He regards it, in fact, as a case of Anthropomorphism. The meaning of this accusation cannot be that we are trying to explain the course of nature according to the maxims of human reason, for no explanation could possibly help us that did not conform to reason, the meaning must be that it unduly or improperly likens the action of nature to the proceedings of human beings, that it explains what we see around us by assuming it to be done as a human workman would do it. This raises the question how far we can venture to make the human mind a standard by which to measure the universe.

The answer is that we have a firm and inevitable belief that the world is reasonable, and so far as that brings us we may go and we must go. On this belief we build our Philosophy, our Science and our Common Sense, for these are only three directions in which the belief that the world is reasonable works out. Now this belief means that nothing ever happens or can happen contrary to the principles of human reason. It may not always give us much that is positive to go upon, but it is very strong in negations. For our belief amounts to this, that there is only one kind of reason and that our reason is of that kind. If we had not this belief we could not argue about these questions or, indeed, about any questions at all. For if we could suppose that human reason did not give us the principles on which everything happens we could never make any deductions from experience. In fact, if our reason did not correspond to the reason that governs the world we could not understand our surroundings well enough to live in them. As M. Bergson argues about the course of evolution we must suppose that he believes that it has conformed to the principles of human reason.

In what, then, does he find our view defective? He ascribes to us the idea of working by bringing parts together. This he calls human, and compares it with the natural plan of formation by dissociation and division. The natural way he calls organising, the human he calls manufacturing. In manufacturing the process is one of gathering in material from the outside and bringing it together so that each part may fit into its proper place and the whole may be a machine. The process of organising begins from the centre and works outwards; from the smallest possible space it expands explosively and grows into a complex organism. It is not a process of adding cell to cell, but rather a process of dividing and subdividing the cell from which it begins.

This is, of course, an attempt to express a real difference between human products and the productions of nature. It might be otherwise put by saying that plants and animals grow but machines are put together. But it does not affect the judgments of reason at all, it only marks the nature of human hands. Men have only hands to work with and they can only do the sort of things that hands are made for. The growth of an animal or plant is certainly a sort of work that could not be carried out by the agency of two hands having five fingers on each. There is much in it that is quite beyond our powers. But there is nothing in it beyond our reason, and so we are fully persuaded that in the growth and evolution of plant or animal nothing contrary to reason can happen.

But, after all, M. Bergson's contrast is grossly exaggerated. The process of growth does proceed by the assembling of parts from without. The contrast with human workmanship does not rest in this but in the fact that the material brought in from the outside is not first formed into subordinate parts of the machine and then added to it, but that it is first merely worked up into a sort of compound which is the stuff of which the machine is constructed, and then in this state being added to the machine it takes its final form in the machine itself. The organism grows from carbon, oxygen, nitrogen and other kinds of matter, which are first taken in and worked up into protoplasm, and this being added to the growing organism falls into its proper place. But there is nothing in all this to withdraw the process from the dominion of reason. In the work of human hands we see the motion and the guidance more clearly separated, while in the growth of the organism they are more closely combined, but in each case we are equally justified in saying that inert matter does not guide itself or do more than pass on the form and design which it has received, and that the only way in which reason can allow that any new guidance could arise or any additional complexity could be brought in is by the action of conscious intelligence. We have not in any way attempted to overlook the limits of human action or the bounds of human ability, but the limitations of our powers do not affect the dominion of our reason and we can confidently pronounce judgment upon many things that we cannot imitate. And thus we hold that in the pecten's eye we have ample evidence of purpose and design.

CHAPTER XX

THE ASYMMETRY OF THE PLAICE

IT would, no doubt, be too much to expect that a housekeeper doing the family marketing or a fisherman hauling his net should have a mind at leisure for other thoughts than those relating to the business in hand. But an observant mind will carry away from the most engrossing occupation many a recollection that may afterwards form a profitable subject for thought, and that more especially from occupations which bring about any kind of contact with the wonderful organisms with which the world is stored. Let a mere beginning be made, let but a hint be given of what may be seen with care and attention, and the thought returns from time to time, little things are noticed one by one and an abiding interest is formed which will brighten many a dull day and relieve the tedium of a monotonous routine. It would not be rash to say that there is in the structure and life history of an ordinary flat-fish enough to give a new interest to a trawler's deck or a fishmonger's counter.

We shall take the plaice as a typical flat-fish, as it is one that inhabits our waters, is known to everyone and whose structure and ways of life have been carefully investigated and described. This fish, when mature, lives on the sea bottom where the water is from twenty to fifty fathoms deep. It is found also in deeper waters, but is not believed to exist where the depth exceeds a hundred fathoms. Smaller fish not mature but of marketable size are found in shallower waters, for the young fish at first takes to shallow places near the shore and goes deeper and farther out as it gets older.

A plaice that is twenty-four inches long and fourteen inches wide is a large one. The largest of which a reliable record can be found was thirty-three inches in length and twenty-one in width and weighed fifteen pounds.[1] It has been proposed to make it illegal to sell plaice of less than eight inches in length, and regulations of such a character have been made in several European countries.

The plaice is generally caught by trawling. Like other ground-fish it is rather sluggish in its movements and does not travel far or come to the surface. We are able, therefore, to follow it through its whole history without at any time finding that it has gone out of our reach. This is convenient for the fisherman because it gives him steady occupation and a return that may be counted on, and for the naturalist because he comes to know more about the plaice than he can know about fishes that hide themselves from time to time in deep water where he cannot get at them or find out what they are doing. It is what the naturalist has observed of the life history of the plaice that makes it a suitable case for the application of our argument.

We begin with a feature common to the plaice and other flat-fishes, such as the sole, flounder and dab. It passes its life on the sea bottom, the side next the ground is white and the side which is turned up is of a dark colour, but this side which is turned up is really a side and not the fish's back, as a careless observer might imagine. That it is really the side may be ascertained by anyone who cuts a plaice up and notices its bones and the position of the different bodily organs. The plaice lies on its left side, and its mouth shows it, for the opening is nearly vertical, as it would be in the case of any fish that laid itself down on one side, and not horizontal, as would be the mouth of a fish in its ordinary position. If the plaice is compared with a fish that keeps to the bottom but does not lie on its side, such as the skate, all this will become quite evident.

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[1] Our best authority on the plaice is a *Memoir* by F. J. Cole and J. Johnstone published in the *Transactions of the Liverpool Biological Society for* 1902. It may also be had in a separate form.

But the remarkable thing about the plaice is that both of its eyes are on the upper side, that is to say, both on the right side, a most remarkable case of asymmetry or crookedness. It is evident that an eye upon the under side would be of no use to the fish, it would even be a disadvantage, because it would be so liable to be hurt by contact with stones, shells and weeds, and by getting grains of sand and other small things into it. And, therefore, if we had been asked what would happen to the lower eye of a fish which took to lying on its side we would have been very likely to answer that the eye would get small, like the mole's eyes, from want of use and finally disappear, and that the fish would have to get on as best it could with one eye. This would have been the easiest way of settling the question, and perhaps it might have done fairly well in practice, but what has actually happened is much better for the plaice, for two eyes are evidently better than one and it has them both on its right side and, therefore, both looking upward.

Those who are able to dissect the skull of the plaice for themselves, or who consult the memoir already referred to, will be able to note in detail how the left eye is made to appear on the right side. As a general and simplified explanation we may say that in that part of the skull which supports the eyes the bones have been twisted over and some of them crushed or altered in shape so that the right eye has moved on a little and made room for the left eye, which has moved over from the other side and come a little nearer to its companion. This twisting of the bones has only affected the part of the head which carries the eyes. Although both eyes look upward the plaice is still altogether lying on its side. Now we know that it is descended from a remote ancestor which swam in an upright position and had its eyes one on each side in the position usual to fishes, but how we get a glimpse of this remote ancestor and what help we have towards imagining how the change came about will appear more clearly when a sketch has been given of the life of a plaice from the very beginning.

The spawning-grounds of the plaice are well known to the trawlers. There the fish are found crowded together in the season, which lasts for several months. In the seas about the British Isles spawning begins in January or February and goes on to the end of April or May. For any one fish the spawning time lasts for about a fortnight. The eggs are lighter than sea-water and consequently float on the surface from the first. They are hatched about the seventeenth day, but the little fish does not assume the proper form of a plaice until six weeks after it has left the egg. For the first thirty days of this period it is perfectly symmetrical. It swims in an upright position and its eyes are opposite to one another, one on each side, as in all symmetrical fishes. It is here that we get a glimpse of the remote symmetrical ancestor from whom the plaice is descended. All animals in the course of their development go through a kind of condensed summary of the history of the race. Some chapters of the history may be omitted and some may pass by so rapidly that they become hard to recognise, but the general character of the history may be easily seen from what is given. We see, then, that the ancestry of the plaice runs back to a symmetrical progenitor, and this agrees with the testimony of the comparative anatomist who finds close resemblances in form and structure and the marks of near relationship amongst symmetrical fish such as the cod. The crookedness or asymmetry of the plaice is a character acquired in the course of its evolution as a fish.

The young plaice begins to acquire this character when it has been hatched about thirty days. Then the movement of the bones of the skull begins, which when completed brings the left eye round to the right side. When this movement is nearly accomplished the plaice begins to descend, and when it is completed it rests on the bottom, where it is to pass the rest of its life. It is now a perfect plaice, but only half an inch in length. But as the young plaice can only live in shallow water it must at this period of its life find itself near the shore. It follows that during the whole time of its existence since it floated up from the spawning-ground as an egg it has been steadily drifting towards shore, and now at the critical time when it must change its way of life it finds itself in a suitable position. There are many places in our home seas which fulfil all the necessary conditions, as the set of tides and currents brings the young fish at the proper time into such surroundings as they require. If any fish should spawn where these conditions are not fulfilled they would, of course, leave no posterity.

After the plaice has taken to the sea bottom it goes every year farther from shore, getting continually into deeper water until it arrives at maturity and finds itself in water of twenty fathoms or more in depth. It is not, however, known how long this period lasts as naturalists have not been able to follow the development of the fish so closely as to tell its age after the third or fourth year.

We have now to ask how the change in the position of the plaice's eyes may be thought to have been brought about in the course of its evolution. By those naturalists who suppose that Darwin's theory of the Natural Selection of Chance Variations will account not merely for a good deal but for everything that has happened in the course of evolution great efforts have been made to show how we may conceive this change to have come to pass. Some, indeed, have given up the attempt and declare that they are content to accept it as the result of Natural Selection without seeing how it could have come about. This, however, is to give up the theory as an explanation and to keep it as a mystery. The use of an explanation is to help us to see how things may have happened, and, therefore, if this theory does not enable us to see how things happened in this case it is not applicable to it. Those who try to make the theory an explanation suppose that the plaice being originally a thin fish something like the Johnny Dory first took to lying on its side and then the movement of the eyes followed. They do not face the point that an eye in contact with the ground would be a source of weakness and disease, that in other cases eyes which were likely to become causes of disease or weakness have been got rid of, and that this is an operation which appears to be satisfactorily accounted for by the Natural Selection of Chance Variations. The first thing, then, that we ask from this explanation is to show why Natural Selection should not act in its usual way.

What they do suppose is that the plaice having acquired the habit of lying on its side, any chance movement of the eye which brought it nearer to the light would be of some advantage to the fish and would therefore be preserved. But nothing can be preserved by Natural Selection unless it is so advantageous that the individuals having it will survive when others perish, and no imperceptible or very small movement of an eye could have so great an effect. But what right have we to expect that any movement of the eye would occur? Do such movements occur in the eyes of fish which would derive no benefit from them? We must remember that this movement is a change or twist in the bones of the skull, affecting all the bones right round in a belt in the region of the eyes, but not carrying with it the bones in the region of the mouth. Do such movements occur in the bones of other fishes, and do they visibly displace their eyes? If not, we cannot reckon on them as chance movements, and so far from expecting them in the case of the plaice we ought to suppose that its skull would be at least as stable as the skulls of other fishes. But some naturalists take it for granted that if any change would be useful to an organism that particular change may be looked for. This is altogether to give up chance and to suppose that some power exists which sees what will be useful in the future and provides for its beginnings in the present. The movement of the plaice's eye, or rather eyes, is really a very complex operation, involving either a series of simultaneous changes tending in the same direction and occurring in many bones or a general pressure on the whole region so applied as to bring about the necessary movement. That all these simultaneous changes should concur to produce the one desirable result as their sum total is not a mere single chance, it is the combination of a great number of chances occurring at the same moment, and is not an easy or explanatory supposition. On the other hand, the power that by a general pressure could twist the skull round so neatly cannot be either Chance Variation or Natural Selection, it must be something that understands and foresees.

But ought we to imagine the change occurring in this way? should our explanation represent the plaice as first taking to lying on its side and then acquiring its twisted skull? The history of the young fish may at least suggest another way of looking at it. It is said that the development of the individual gives us a sketch of the evolution of the race. We cannot, of course, insist on this principle as a guide to every minute detail. Much may be lost by compression or abridgment, it is even possible that the order of events may be sometimes displaced, and some things may be acquired in the course of evolution which will attach themselves to any, even the earliest period of the animal's life. Yet, after making all these allowances, we may ask whether the life history of the young plaice does not suggest a better way of thinking about the evolution of the species.

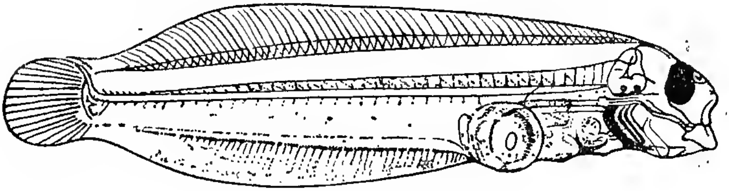

FIG. 23.—YOUNG PLAICE.

In the larval state just before it begins to turn over on one side. × 6.

By kind permission after Ehrenbaum, *Eier und Larven von Fischen der Deutschen Bucht.* Wiss. Meeresuntersuch. Kiel. Komm. Bd. 2, Heft I., A 6th. I, Plate 4, Fig. 15. 1896.

The authors of the memoir already quoted observed the young plaice in a tank during the period of change (see Fig. 23). Under such circumstances the time it took was about a fortnight. But the change came first, and when it had come the fish sought the bottom. This is not, however, the most remarkable point. What is chiefly to be noted is that the change was continuous and that as it became more and more developed the little fish turned more and more out of its upright position and swam more nearly on its side until, when the change was completed, it was swimming altogether on one side. And all the time it swam at such an angle as to keep its two eyes on the same level. This is a fact which was not anticipated in any theory of evolution or in the speculations which were based on any such theory. The fish keeps its eyes on the same level, and to do this it swims at any angle from the perpendicular that may be necessary. It certainly looks as though the change in the position of the eyes controlled and caused the change in the position assumed in swimming. Now if this is the fruit of inheritance and represents the state of things when the asymmetry was acquired, it is altogether impossible to suppose that we are looking at the result of the selection of chance variations. If such variations could be imagined it would be impossible to imagine how they could be selected. But if we are looking at the result of controlled and directed variation the order of events does not create any difficulty. But if in order to escape the force of these considerations we are asked to suppose that this is not a picture of the original change, but something that came in afterwards, we have to find some reason why the original order was suppressed and why this particular and very remarkable course of events was brought in instead, and more especially we have to find out why we are to suppose that the position of its eyes on the same level, which is of so great importance to the fish now, was formerly a matter of indifference.

May we not say as the result of our consideration of the plaice's asymmetry that to account for it without ascribing it to a conscious and foreseeing intelligence is not merely difficult but quite impossible ?

CHAPTER XXI

INSTINCT

THE enquiries which we have been making into the traces which can now be found of certain steps in evolutionary progress are instances or samples of the thoughts and reasonings which occur to one who sees clearly that no new construction can be due to chance, and which acquire increased and, indeed, irresistible force when he is able to recognise the distinction between the limited chance which may deal with constructions and designs already existing and the pure chance to which appeal must be made for any augmentation or novelty of design. The subject of Instinct, however, still remains untouched, and without something said about it our series of meditations would not be complete. For structure is often correlative to instinct, the two work together and neither is intelligible by itself. Whatever explanation we may give of either we are immediately impelled to try whether it is capable of explaining the other.

The greatest difficulty in the way of any clear thought about instinct is the difficulty of saying precisely what it is. The products of Nature have a way of shading off into something else, so that it becomes nearly impossible to mark out an exact boundary between two classes. When we have done our best some intermediate form will turn up and defy us to say on which side of the boundary it ought to be placed. So regularly does this happen that when a naturalist finds two nearly related species perfectly distinct and satisfactorily defined, his most likely and natural thought is, that the intermediate and puzzling forms once existed but have become extinct. But few things shade off in a more perplexing way than instinct. It is allied on the one side to mechanical action and the necessary response of an organism to its surroundings, and on the other side to habit and even to intelligent action, so that it is impossible to say where the boundary lies. And then it is even more perplexing to find that instinct may combine with any other cause of action and may be modified by it, so that it is often not easy to say how far a certain action is instinctive and how far it is intelligent.

It is well to be conscious of these difficulties, but it is satisfactory to find that for our purpose it is not necessary to face them. We may admit that possibly some actions called instinctive are merely the working of mechanism, which, being what it is, could not work in any other way. We may suppose it possible that a habit resulting from intelligent action may be inherited and, being performed without intelligence, may become truly instinctive, and we may pass these questions and other similar questions by as not our immediate concern, since we are only going to ask whether there are any actions properly called instinctive, of such a nature that they cannot be explained without attributing their origin to a conscious intelligence other than that of the animal whose instincts they are. Instincts may be of different kinds, they may have originated in many ways. Some of them may be due to the Natural Selection of chance variations of action, some of them may be due to the inheritance of habits once intelligently acquired. We only ask whether there are any which are proper instances for our present argument.

As it is thus incumbent on us to avoid all difficulties except those with which we are immediately concerned, it will not be hard to find a satisfactory definition of instinct or at least to lay down the marks by which an instinctive action may be known. An instinctive action then is (1) the action of an animal, (2) performed by all the members of a definite group, (3) when certain circumstances arise, (4) without instruction or previous experience, (5) accompanied by consciousness. By the first condition is meant that it is the action of the whole organism, the whole animal as we may say and not the mere reflex action of a single limb. The group mentioned in the second condition may be a species or the animals of either sex in one species, or those of a certain age, or who are otherwise by some definite characteristics distinguished as a separate group. The wonder and admiration with which instinct is regarded are chiefly evoked by its conformity to the third and fourth conditions. When the proper circumstances occur then, without receiving any instruction or waiting for any example, the animal unhesitatingly does the proper thing. The young chicken pecks at the first small objects it encounters, the young water-fowl swims and dives without waiting to be told whether that is what it ought to do, when the queen bee dies and there are no young queens coming forward the workers immediately alter the shape of certain cells and change the food of the larvæ, so that some that would otherwise have been workers now come out as queens. We wonder how it is that animals which do not on the whole show very much intelligence seem to be suddenly on one particular occasion endued with such skill and wisdom that they both know what ought to be done and are able to set to work to do it. Sometimes, when considering the remarkable things that we see them do, we are inclined to attribute to the lower animals a degree of intelligence which they are far from possessing. The intelligence of ants and bees in particular has thus been absurdly overrated. But the researches of Lord Avebury and others have shown how very limited it is and how very far their actions exceed in wisdom any thoughts or designs which they can possibly be supposed to entertain.

But, interesting as this subject is, we must not let ourselves be drawn aside from our immediate enquiry. We are not seeking to determine the bounds of instinct or to settle its possibilities, we are only concerned to know whether there are any instincts which cannot be supposed to have come into existence without the assistance or supervision of a conscious and active intelligence.

A good example of such an instinct is given us by a little beetle, *Sitaris humeralis*, whose larvæ live at the expense of bees of the genus *Anthophora.*[1] The beetle lays its eggs near the entrance to the bees' nest. Out of these come little larvæ of a very active habit, which seek to attach themselves to some hairy object. The only object on which they can profitably seize is the body of the *Anthophora* bee, but their instinct at this stage is very indiscriminating and many of them get hold of other hairy insects and perish in consequence. However, the *Sitaris* lays a great number of eggs and some of them find their way to their proper host. The male bee is hatched first and comes out of the nest nearly a month before the female, so that it is probable that the greater number of the larvæ become attached to the male, but they take an opportunity of transferring themselves to the female and remain with her until she lays an egg. This egg is laid in a cell containing a supply of honey, upon which it floats, and the cell is then closed by the bee. But at the moment when the egg is laid the *Sitaris* gets on it and remains there, using the egg as a raft and feeding on its contents. As it can neither float on the honey nor feed on it it would perish if it left the egg. After living in this way for about a week it undergoes a moult and then assumes another form, admirably adapted for floating on the honey and able to use it as food. It now spends about forty days in consuming the honey, after which it changes its form again and passing into the pupal stage appears as a perfect insect in the following month.

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[1] *The Cambridge Natural History,* Vol. VI., p. 272.

The series of transformations may be completed between May and August or September.

It is quite evident that the intelligence of the insect itself can have no effect upon its very curious history. It only goes through this process once in its life and cannot be supposed to be able at any stage to anticipate what is coming. Nor if it could remember its own experience has it any way of instructing or influencing its posterity, so that we have here an instinct which, if it is due to any intelligence, is certainly not due to that of the insect.

But it is not at all more possible to ascribe it to chance, for it is very minute and discriminating from the time when the larva gets into contact with the *Anthophora*, and both the instinct of the larva and its transformations are exactly such as to enable it to profit by the habits of this particular kind of bee. There is here an instance not merely of order but of a very elaborate and complex order, and it is unthinkable that chance, which is incapable of giving rise to order, should have produced this complicated scheme of life. It only remains possible for us to suppose that the course of evolution was supervised and controlled by some conscious intelligence which guided the development of this little beetle.

Another insect which exhibits a very remarkable instinct is the Yucca moth (*Pronuba synthetica*). The Yucca is a plant which is a native of North America. It has been introduced into this country but does not produce seed here, as it cannot fertilise itself or be fertilised by the insects which usually visit plants. It can only be fertilised by the Yucca moth.[1] The female of this insect collects from the stamens a large mass of pollen, which it forms into a ball and holds by means of those appendages to its head known as the maxillary tentacles, which in this insect are of a peculiar shape and suitable for that purpose. The moth then goes to another flower and lays an egg in the pistil, after doing which she applies the pollen which she has collected to the pistil so as to secure the fertilisation of the flower. The egg is laid in the middle of the undeveloped seeds, which now swell and grow, and provide food for the larva. About half of the seeds are thus consumed and the rest remain for the propagation of the plant.

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[1] *Cambridge Natural History*, Vol. VI., p. 432.

Here, again, we have a case in which an insect performs a remarkable action which, if it were purposely and intelligently done, would show a considerable knowledge of natural history. But it is quite impossible to suppose that the moth knows what it is doing and equally impossible to suppose that such an elaborate fitting on one thing to another came about by chance. The origin of this instinct must surely be due to intelligence.

M. Bergson treats instinct in a way of his own. For him instinct is sympathy ;[1] it is something like the unreflecting sympathy and antipathy we experience in ourselves.[2] It is not intelligence. Yet it is a sort of knowledge. " Everything happens *as if* the larva of the *Sitaris* from the moment it was hatched knew that the male *Anthophora* would emerge from the passage " and knew what would happen after that.[3] This kind of knowledge he calls intuition. But there is nothing to show us that the insect at all knows what it is doing, but everything to lead us to suppose that only just when the moment arrives, when the proper circumstances occur, is the instinct excited which causes the action. It is not in the least degree likely that in performing any one action of the series there is any expectation of the next. Take the instances chosen by M. Bergson to show the fullest development of this instinctive sympathy or innate knowledge, namely, the proceedings of certain solitary wasps. One of these is a species of *Sphex*. This wasp makes a burrow in the ground.[4] First, there is a horizontal gallery two or three inches long, and then a downward turn or well two or three inches deep at the bottom of which an oval chamber is formed. Three or four crickets are put into this chamber, an egg is laid in it and it is closed up. A second chamber is now formed beside the first and similarly stored and closed, and perhaps a third and even a fourth. But then the burrow is abandoned and the wasp goes elsewhere and makes another nest. The working time of the insect lasts for about a month, and in this period she usually constructs ten of these nests. When putting the crickets into the nest the *Sphex* stings them, but not in such a way as to kill them. They are only paralysed, and the larva when it comes to feed on them will find them alive but helpless. Now what M. Bergson dwells on is that the cricket has three principal nerve centres, and it is just at these three centres that the wasp stings its victim.[1] Another wasp of similar habits, *Ammophila Hirsuta*, which forms a nest in the same way, but provisions it with caterpillars which have nine distinct nerve centres, gives nine successive strokes of the sting, one to each centre. The wasp is supposed to have a sympathetic knowledge, or rather feeling, of the nature and the anatomy of the caterpillar in accordance with which it guides its sting to the nine principal points in the nervous system of its victim. Dr. and Mrs. Peckham give us a most interesting description of the American representatives of the genera *Sphex* and *Ammophila*.[2] They did not find that the wasps stung their prey with very remarkable accuracy. Sometimes it was so little hurt that the larva found it quite lively, sometimes it was so stung as to remain paralysed until it was wanted by the larva, sometimes it had died when the larva was ready for it and sometimes it was quite putrescent. But in whatever state it was found it seemed to do equally well, as the larva was always able to live and thrive on it. They certainly found nothing which might not be ascribed to the action of an instinct simply excited and guided by the appearance of the cricket or caterpillar without any mysterious sympathetic insight or knowledge. The wasps also which they observed never seemed to understand the action of parasitical flies which tried to introduce their eggs into the nests that they were making, nor to see that this would injure their offspring. We have good authority for stating that wasps of the genus *Bembex* which feed their own larvæ make no effort to destroy the parasites by which their larvæ are starved and even killed, but go on bringing food to be devoured by a company of these intruders.[1]

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[1] *Creative Evolution*, p. 186. [2] *Op. cit.*, p. 184. [3] *Op. cit.*, p. 154.

[4] *Cambridge Natural History*, Vol. VI., p. 108.

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[1] *Creative Evolution*, p. 182.

[2] *Wasps Social and Solitary*, by George W. Peckham and Elizabeth G. Peckham.

It is impossible to carry away from such accounts of their behaviour a belief that these wasps have any knowledge of what they are doing, whether you call the knowledge intuitive, sympathetic, or by any other name. They do not know that they are providing for their posterity; they do not know that there is such a thing as posterity. But at a certain time from the growth and development of their own bodies, and from the things they feel and see, certain emotions arise in them, and they are impelled to perform certain actions. The sight of the caterpillar's body with the marks which show its divisions is the stimulus which impels the wasp to sting it on these marks. Instinct is an impulse which arises on a stimulus, and the observations of every careful observer go to show that instinct is always blind. The wonderful foresight and contrivance displayed by some actions instinctively performed cannot be ascribed to the insect which performs them. They must be due to the source from which instinct arises, which must therefore be believed to be capable of exercising foresight and forming a design.

The argument from instinct is shortly this: We find that certain animals have in their own constitution as it is inherited from their ancestors a disposition to do certain things when certain circumstances arise. In some cases the things so done form an elaborate course of action necessary for the survival of the individual or of the race. How did this constitution or disposition arise? It cannot be due to the wisdom of the animal or of its ancestors. It cannot be due to chance. Nothing new ever comes by chance, and this is not only something that must have come in as a new thing but it must also have been very complicated and elaborate in its newness. The only possible explanation of its existence is that it is due to the conscious action of an intelligent agent.

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[1] *Wasps Social and Solitary*, p. 132. *Cambridge Natural History*, Vol. VI., p. 121.

In no family of insects other than the ants is there greater difficulty in imagining how natural selection or any force, impetus, tendency, law, or agent of any kind not possessed of consciousness and having a purpose could bring their instincts into being. The leaf-cutting ants of the genus *Atta* may be taken as an illustration. These insects are found in the warmer parts of America, and are so destructive that they make the cultivation of useful fruit trees almost impossible. Beet has described their ravages in Nicaragua.[1] He says that they prefer imported to native trees, probably because the native species are in some way more or less protected against them. He was told that in certain places it seemed hardly worth anybody's while to plant an orange tree, so certain was it to suffer from their depredations. When they attack a tree they cut round pieces out of the leaves, which they carry to their nests. The nest is a very extensive system of galleries and chambers excavated in the ground and going down to a considerable depth. The earth which is removed in making it is left on the surface and forms a wide, low mound bare of vegetation. In the nests are special chambers where the leaves which are brought in are stored, and these are provided with channels leading to the surface which look as if they were intended for ventilation. But the leaves are not the food of the ants, they are brought in for another purpose. They are cut from the tree and carried to the nest by workers of a large size, for these are amongst the largest of the ant kind, but they are there received by a set of very small workers which cut them into fragments, make them into balls and pack them away in the proper chambers. There a fungus grows through them and forms little white swellings which are the ants' food. Competent naturalists have satisfied themselves that this is a true cultivation of the fungus by the ants,[1] for while in the nests it is always a mycelium producing ants' food. When removed from the nests it produces conidia. Beet also noticed that the ants were very careful not to bring the leaves on which the fungus is cultivated into the nest either too wet or too dry. When the weather was too dry and hot they ceased working and waited for a favourable opportunity; when the leaves were made too wet by showers they were left to dry. The fungus which these ants cultivate is called *Rozites gongylaphora*. By what means they keep it from mouldiness and make it always produce the white knobs on which they feed is not known. Here we have a very complicated instinct carried out by two sets of workers of different shapes and sizes, each having its structure suited to its instinct and its instinct to its structure, and both together forming one machine for the production of the ants' food. The working of this instinct depends on its being co-ordinated with the properties of the leaves and the properties of the fungus so that everything in this complex arrangement fits into everything else.

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[1] *The Naturalist in Nicaragua,* p. 71.

Like all ants the *Atta* are propagated by one or by a few queens in each nest. The workers are unfertile females and leave no posterity. They cannot therefore transmit any skill they may acquire to future generations. This makes it more difficult to ascribe the origin of their instincts to Natural Selection, because it becomes necessary to suppose the selection to act not on individuals but on nests or swarms, and the variations to be selected will be variations in the swarm. But the variations must all occur in individuals, and many variations of a favourable nature in many individuals must coincide and be co-ordinated in order to produce a favourable variation in the swarm. So that chance would be required to do a good deal of fitting and contriving to bring about something that selection might deal with. And as we must suppose that the leaf-cutting ants are descended from insects which were not leaf-cutters, what chance would have to produce would be the whole complex arrangement of a leaf-cutter's nest with the organisation and instincts of each class of its inhabitants. It is no wonder that even those naturalists who have not come to see the distinction between bringing out the possibilities of existing order and producing some additional order which is really new, and who therefore feel that chance may do something new and orderly, find it hard to believe that it can do so much as this and are looking round for something to help out Natural Selection by producing the necessary variations.

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[1] *Cambridge Natural History*, Vol. VI., p. 167.

But nothing can be found besides chance and consciousness to which the beginning of order can in any case be attributed. This is in no way remarkable, because while each of these is in itself a very positive, clear conception, with regard to one another they are contraries, and no clear concept can be formed of anything distinct from both and yet capable of giving origin to order. Necessity is only existing order, and merely passes on what it contains. It produces nothing new, and every other substitute, such as law, impetus, *élan*, tendency, vitality, nature, if taken to be the origin of new, increased or higher order will be found to be either consciousness or chance, or a mixture of the two. Let me illustrate this by a story.

When Typhon made war against Zeus and was defeated he was punished by being buried in Sicily under the weight of Mount Etna. Here he groaned and heaved, desiring with unutterable longing to be free, yet knowing of no way by which he might attain his liberty. For though his strength was such that he could stir the mountain he was by no means able to get from under it. And for many centuries the inhabitants of that neighbourhood could hear his groans, and sometimes houses and trees were overturned by his struggles. But at length they began to notice that as he shook and moved the mountain and jostled about the various minerals and other substances which it contained so that they were brought in the course of time into every possible position and relation to one another, very curious and wonderful things were formed. And they got into the habit of carrying away such things as they found useful, and of imitating them and making similar things themselves, and these things they often placed on the mountain in order that by the shaking and commotion which went on there they might be brought into contact with crude minerals and other things, formed and shaped as has been described, and so receive additions and improvements. In this way by slow degrees were evolved many things which have proved to be of the greatest advantage to the human race. For at first these people were almost destitute of tools and weapons, having nothing better in that way than flints reduced by chipping and grinding to useful shapes. But they found on the mountain better implements, first of bronze and then of iron and steel, and at first of a simple form and then by degrees getting more and more complicated and having uses which they sometimes for a while found it difficult to understand. And most of the great and useful inventions on which we depend for so much of our comfort were thus produced in Mount Etna, although they are currently supposed to have been made by various inventors. But those who are acquainted with their true history know that these supposed inventors were really nothing more than importers.

After a while it appeared that all these productions of the mountain were evolving in a certain direction, and tended towards the release of the prisoner. For though he knew nothing about machinery and was quite incapable of devising or inventing anything yet he always shook the mountain with an intense desire to be free, and the inhabitants of the district knowing of his desire always picked out and selected such implements or machines as were best fitted to break or destroy rocks, and returned these in preference to any others to be further shaken about in the mountain and to receive improvements. Hence it is not wonderful that the final result of his efforts after a very long course of evolution and the rejection of hundreds and thousands of machines as failures was the production of a pneumatic rock-boring machine and suitable dynamite cartridges. Nor is it strange that this machine being set to work brought about the liberation of the giant. Having gained wisdom by his misfortunes he no longer tried to carry on the warfare to which they were due, but was glad to be allowed to live quietly in retirement, where it is said by meditating on his own experiences he has already produced several windy theories of Evolution which he has published under the names of eminent naturalists and philosophers.

Now I submit that this story is very far from being a caricature or parody. It is on the contrary a fair attempt to bring into relief the true character of certain theories. The part allotted to the imprisoned giant is that of jostling things about. And what more can be attributed to any force to which foresight and purpose are denied? To make an arrangement to set things in order is to look forward and place one thing with regard to what is coming next. But what is coming next has not yet come; its place and relations are not yet found, it can neither be seen nor felt, it can only be thought of. And so things can be set in order only by an agent that can think, and know, and look forward and design. An unconscious force can only stir things about in an aimless and ineffectual way.

But I have had to suppose the giant to be conscious and longing for liberty merely to account for his continued struggles. And this illustrates the character of all theories which rely upon a force which has an ideal aim. Even the most blind and ineffectual struggle for an ideal must proceed from a conscious intelligence. To a prisoner liberty is an ideal, it is something which does not exist but which may be contemplated as an idea, and so become an object and an aim. And progress, advancement, imprisonment, development are no less ideals that can only reside in a mind and only become forces or guides by being contemplated by a conscious intelligence. It is in vain then that impetus, upward tendency, *élan*, or anything else of the kind is brought in as a substitute for consciousness and teleology. These are themselves teleological and imply consciousness. The consciousness may indeed be blind or enlightened. If it is blind it is the giant under the mountain who can only shake and jostle, if it is enlightened it is purpose and design. When thoughts and theories are strictly catechised they are found to contain nothing which can be supposed to account for order, but chance on the one hand and design on the other, and when the question is plainly put to us Is it chance or design? our answer can never be really doubtful.

Is it necessary now to ask whether the struggles of the giant under the mountain or any other blind force would be more likely to produce a nest of ants than a pneumatic rock-boring machine?

PART IV

OBJECTIONS CONSIDERED

CHAPTER XXII

SOME OBJECTIONS

ALTHOUGH the argument which has been laid before the reader is complete in itself, it may be satisfactory by way of supplement or appendix to take account of some objections which are made to it. I don't think that any objections will much affect those who have really assimilated the argument, because it has of itself more force and weight than anything which can be urged against it, and is able to bear down opposition by its own vigour. But for those who hesitate a few words may be of use.

The general objection which is offered to every argument of this description may be treated under three heads. First it is said that we cannot carry on such an enquiry, secondly that we have not succeeded, and thirdly that what we offer as the result is inadequate and unacceptable. In other words, our power to do what we propose is questioned, our success in doing it denied, and the conclusion that we arrive at is said to be futile. Now as to the first or preliminary objection, that we have not powers adequate to this enquiry, we meet it thus.

The objection is that the powers of the human intellect are able to deal with the facts of life but are not capable of enquiring into life itself; that they can grapple with Nature as a going concern but are not able to comprehend or make any report on its origin; that they can report and classify events but cannot explain causes. The human intellect, it is said, has arisen in the course of evolution, and is able to understand, criticise and use the results of evolution, but cannot explain the evolutionary process from which it arises. Its objects are practical, and only when directing practice can it be of use.

Now of all this we say that it comes at the wrong time and place. It might be asserted that this was the result of such an enquiry as we are engaged in, but with what show of reason can it be alleged as an objection to the enquiry itself? How can we know what the powers of the intellect are except by making the experiment and trying what we can do? If there is a stone wall which confines us within certain limits let us at least have the satisfaction of knocking our heads against it before we admit its existence. What looks like a wall at a distance may prove when assailed to be nothing more than a fog bank, which will open to let us pass. The only reason which is ever given why we should be content to confine our attention to the events we meet with in the world in which we live is that our intellect is merely designed to guide us through life, as the intelligence of the lower animals guides them. But how is it known that our intellect is only intended to guide us through life? Why are we to suppose that we are intended to have no greater use for a knowledge of the future than a wasp or an ant? May we not just as easily assume that the intellect of man is intended to bring him to the knowledge of God? And is it not by just such an enquiry as ours that we are to determine which hypothesis is to be accepted, and have we not thus determined it?

But the objection takes another form and enters into greater detail. We carry on our reasoning, it is said, by means of certain principles, such for instance as that every event must have a cause. Now these principles apply without doubt or hesitation to every event that may happen within the course of Nature, but we have no right to apply it to the course of Nature itself and to say that that must have a cause, and yet this is what we do when from anything we find in Nature we infer the existence of God.

We cannot accept this position. We cannot admit that the parts must be reasonable, and yet the whole may be unreasonable, that every little thing requires a cause but a great thing does not. Our persuasion is that the universe is reasonable, that is to say that it conforms to the principles which our reason accepts, as a whole and in all its parts. That is to say we cannot feel or make ourselves believe that there is any other kind of reason than the reason that we have, or that what our reason condemns could ever have happened or existed. If every event must have a cause then the first event must have had a cause also; there must have been a First Cause which was not an event. We cannot suppose that at the beginning twice two might have been five or that then, but not now, two straight lines might have enclosed a space, or that this might have happened before the universe was created or after it has come to an end. The fact is that we have certain primary beliefs which spring up in the mind as soon as it begins to exercise its powers. From these we cannot get away, and upon them as first principles we must reason. We cannot indeed prove their truth because to prove them would be to refer them to something more certain or authoritative, and we have nothing of that sort, but we rely on them as conditions or characters of existence, and we say that thus the universe exists and must exist, and this is its nature both in detail and as a whole. The objection only seeks to withdraw some part of existence from our consideration by calling it the beginning and remarking that it must have been different from the continuation. While we allow our thoughts in this way to be dissolved into a vague nebulosity we may imagine that we are persuaded, but let us once focus our attention on the point and we shall find that we are not. There can have been no beginning, there can be no end that is not just as reasonable as what comes between.

In another way an attempt is made to withdraw attention from the point on which the argument turns. The principles of reason, it is said, are principles which apply within experience, that is to say they are applicable to all actual or possible experience. But where there can be no experience they can have no application and therefore no validity. But this does not touch us at all. For we can believe that the angels were present at the creation of this universe in which we live, and we can suppose that we ourselves may be present at the creation of other universes after this shall have passed away. We at least are not discussing anything which to us appears to transcend the bounds of possible experience.

But we claim the right to put the matter in another way. The question which we are to discuss is whether the universe is self-explanatory. We are to ask whether what we find in it is enough to make it intelligible without reference to anything beyond it. Does it reveal itself to us as a self-contained and self-sufficing system which bears within it all that is required to account for its own existence and history. This is surely not an enquiry which transcends experience. It is, on the contrary, the very nature and meaning of experience that we wish to know. When we ask whether the nature and powers of the constituents of the universe as they are revealed in experience are sufficient to account for the facts with which experience makes us acquainted, or whether this material universe is so constituted as to bear witness to a power greater and higher than itself we are surely not pressing the human intellect into regions for which it was designed. On the contrary nothing can be more reasonable than to suppose that if the universe has an intelligent author our intellects might be so designed as to apprehend Him and our experience so contrived as to reveal Him.

From this point of view the modern discovery of Evolution is a very happy addition to the resources of our argument. To Paley and his contemporaries the manifold tokens of order, plan and design exhibited in the world around us were a clear revelation of the existence of a conscious and intelligent designer. The argument could not indeed be resisted. But looking at the species of plants and animals as the science of their day taught them, and taking them for permanent forms which had been from the beginning just what they are now, they were obliged to ascribe all this planning and design to the one moment at which the species was supposed to come into existence. And hence it seemed something remote from the present order of events and almost opposed to its nature. Not that there is anything unreasonable in supposing that the beginning of a series of events might have in it something special and peculiar which would not be communicated to what came after. But the beginning is far away; it seems altogether different from the present; what occurred then may never happen again, and on the whole if we cannot logically reject it we can practically put it out of our thoughts. We can even say that we have no experience of beginnings and know nothing about them, and however futile this may be as an argument it is by no means without force as an evasion.

But now we see the evidences for design not accumulated at the beginning but spread out over the whole course of events. We are not tempted to think of Nature as a machine constructed, wound up and abandoned. We are not oppressed by the thought of a power great indeed and wise and good, but remote, inaccessible and uncommunicative. The whole thing is brought nearer to our thoughts and hearts. We see the design forming part of the process, the designer never absent from His work. Nature speaks to us not of what once was but of what now is. It brings us not to the threshold of the Temple but into the presence of our God.

For the marks of design lose nothing by being spread out in time and coming to us in files instead of in squares. They even gain something in force as they tell us of a design not merely entertained for a moment but remembered and continued for ages. Chance has no power of order or arrangement, and chance has no memory. From Paley's point of view there was one argument against chance, from ours there are two. But above all we are evidently not arguing about what is beyond or above all possible experience. We are contemplating the course of Evolution and noting how it actually happened.

When we come to the second class of objections, those which are brought against the manner in which our enquiry is carried on, we find that they are chiefly founded on the idea of Natural Law. The whole result of modern research, we are told, has been to accentuate and enlarge our views of natural law.

So many things that were at one time otherwise accounted for have been one after another proved to occur in conformity with the laws of nature that it is now received as a settled result of the general deduction from observation which goes by the name of Science that everything is reducible to Natural Law. The whole work of every man of science is devoted to the discovery of Natural Law. Nothing else has any interest or value for him. As for talking to him about Natural Theology you might as well talk to him about schemes for producing perpetual motion.

A great deal has been written in our day about the Laws of Nature, and much of it is very wise and some of it is very foolish. But nothing can be farther from the truth than the assertion that Science is wholly devoted to the discovery of laws of nature. Scientific people are like other people in this, that what they want is not laws but explanations. Wherever an explanation is possible it is given, and where no explanation can be found we have to be content with a law. The laws of nature are in reality the mass of unreduced facts which remain when as much as possible has been explained. They are not the triumphs of the scientist but his problems, they measure not our knowledge but our ignorance. The progress of investigation makes it easy to find examples which will illustrate this point. That some diseases are infectious was once merely an observed fact, that is to say a law of nature. Since the discovery of microbes it can be explained, and consequently it is never presented as a law; we are always given the explanation. To our ancestors the rise and fall of the tides was a mystery. That they did so rise and fall, as we observe, was simply a law of nature and could not be explained. But we can explain the tides by the attraction exercised by the Sun and Moon on the water of the ocean. And therefore the rise and fall of the tides is not spoken of as a law of nature but explained as the result of attraction. Then the attraction is explained by a reference to gravitation, and here we have a law, because gravitation cannot be explained. We can only say that it is a property of matter that every particle of it tends to approach every other particle with a force which varies inversely as the square of the distance. Now if Science delighted only in laws no law could be more satisfactory than the law of gravitation, and yet no scientific person who has to deal with it is satisfied with it, but on the contrary he longs to attack it, vanquish it, and dissolve it, and to put an explanation in its place.

The laws of nature always in the end resolve themselves into the properties of organised or unorganised bodies. That the properties of bodies are constant and uniform, and that similar combinations always produce similar results are the two principles on which natural science depends. They are statements of the uniformity of natural law and the uniformity of natural facts, and put together they comprise all that can be said as to the uniformity which we find in nature.

We have no reason to quarrel with the doctrine of the uniformity of natural law. It is rather our part to insist on it. Nor do we find it necessary to place ourselves in opposition to anyone who has a law of nature to announce.

Such announcements as have been generally accepted by the world of Science have always been useful to us. But we are as anxious as any scientific person can be to have things explained, and we agree with the scientists in liking to have them explained by an appeal to such properties and qualities only as things are known to possess. Now our contention is that material things have no spontaneity, design, or foresight. In this we are upheld by all the sciences. Where would Chemistry be, for instance, if spontaneity could be attributed to chemical elements? But without spontaneity and foresight we cannot explain any new organisation or any increased complexity in an old organisation. And so we urge that the progress of evolution cannot be explained without ascribing it to the guidance of conscious intelligence. For those who are willing to consider this question in detail we have entered into details, to those who refuse to consider it and tell us that science cannot take any explanation into account except such as is founded on the material properties of natural objects, and that failing this it can only record observed uniformities we answer that this is not Science standing on its dignity but only Science in a sulk. If we are really seeking the truth we will not refuse to accept any results that can be shown to be true. That the powers and properties which can be found in Nature are insufficient to account for the course of Nature we take to be established as true. Let our arguments be examined before our conclusion is rejected.

The whole subject is sometimes waved aside with the remark that it is not worth our while to engage in an enquiry which presupposes the performance of miracles. It is scarcely worth while to engage in any enquiry with a presupposition which determines the result. And a presupposition against miracles is as fatal to sound reasoning as one in their favour. But I would like to point out that into our present argument the question of miracles need not enter. We are concerned to maintain not a miracle but a providential guidance of the course of nature. Miracle and Providence differ in this, that while they are both nothing else than the hand of God, yet Miracle is the hand of God revealed and Providence is the hand of God concealed. What we mean by miracle is the exercise of some force not included amongst the forces of Nature. What we mean by providence is the guiding of natural forces in a certain way. To one thoroughly acquainted with the action of natural forces a miracle would manifest some force above and beyond Nature. In the acts of Providence he would find no forces beyond those he was acquainted with, but he would see that these forces were guided in a direction which they would not themselves have followed. Nobody who takes religion seriously can avoid the question of miracles, but it is not here that it arises.

Another attack is made on the method of enquiries such as ours because they are founded upon the contrast between order and disorder, and also on the contrast between chance and design. The objection consists in denying that there is anything in existence which can justly be called either disorder or chance. We might meet these objections with the psychological argument and ask how we could have these ideas if no such things existed. As we can have no ideas except such as we gain by experience or build up out of what we find in experience it would be necessary for those who say that these ideas are not gained by experience to show the fragments out of which they are built up. If the attempt is made it will be found that these ideas can be constructed out of nothing but themselves. The reader who has gone through the second part of this book will no doubt be so clear on the subject of chance and design that he will see at once that they are not constructed out of anything else, but that our ideas are gained by what we meet in experience.

It may be well, however, to consider an attempt to deny chance and disorder and to account for our having such ideas. This attempt we will find in M. Bergson's writings. We are indebted to him here, as on other occasions, for bringing the objections that can be made to our argument to a focus and giving them a clear statement. His theory is that there are two kinds of order,[1] the order that is willed and the order that is automatic; that which is willed is intentional and teleological, that which is automatic is mechanical and necessary. When I am interested in one kind of order and look for it and find not it but the other I am disappointed, and call the absence of the order I am looking for "disorder." But it is not really anything more than the kind of order I don't want at the moment. It may be well to quote Bergson's example.[2]

"Anyone can be convinced of this by considering the use we make of the idea of disorder in daily life. When I enter a room and pronounce it to be in 'disorder' what do I mean? The position of each object is explained by the automatic movements of the person who has slept in the room or by the efficient causes, whatever they might be, that have caused each article of furniture, clothing, etc., to be where it is: the order in the second sense of the word is perfect. But it is order of the first kind that I am expecting, the order that a methodical person puts into his life, the willed order and not the automatic, so I call the absence of this order 'disorder.' At bottom all there is that is real, perceived and even conceived, in this absence of one of the two kinds of order is the presence of the other. But the second is indifferent to me. *I am interested only in the first*, and I express the presence of the second as a function of the first instead of expressing it, so to speak, as a function of itself by calling it *disorder*."

This is very neatly and clearly put, but not at all to the point. M. Bergson has simply passed over the idea of disorder. What he calls the second kind of order, the automatic or mechanical sort, we have before considered under the name of necessity (see Chapter X). It is really the invariable properties of matter which are always there and always act in the same way. In all our discussions we have taken the existence of these properties for granted. It would be difficult to do anything else. When M. Bergson goes on in the passage following the one quoted to talk of a chaos as a state of things in which the physical world obeys no law, but every particle of matter is actuated by its own will, and every will acts capriciously, he gives us an idea which it is very difficult to grasp. We naturally and necessarily think of matter as having properties, and of these properties as persisting, and this gives us a background of necessity on which order and disorder may be displayed. What M. Bergson calls the mechanical order we always expect and always find, what we call order or disorder is something additional. For order is co-ordination in positions or acts, disorder is the absence of this co-ordination. When I find the furniture and other contents of the room arranged in such a way that one thing stands regularly in relation to another forming straight lines, balanced patterns, symmetrical dispositions, and other arrangements that mark co-ordination I say that they are in order. When I find an absence of co-ordination I say that they are in disorder. The same thing holds good of temporal arrangement. When the players in a band produce the notes from their respective instruments in such a way that the series of notes coming from one instrument fits into the series coming from another instrument and combines with it we call the playing orderly, when this co-ordination fails we call it confusion. But always and everywhere we expect the laws of nature to prevail. We look for them just as much in what we call confusion as in what we call order. If we must call that order which we have preferred to call necessity then our answer to

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[1] *Creative Evolution*, p. 244.

[2] *Ibid.*, p. 245.

M. Bergson is that where we find what we call order there are two kinds of order which prevail simultaneously, where we find what we call confusion there is only one. When I come into the room that he supposes, I find the laws of nature prevailing, the chairs are not walking about on their own account, the particles of matter are not flying loose but are bound together in various objects in the usual way. If he is satisfied with that as order, the room is in order indeed. But I am not satisfied. I want to see everything in its place with respect to everything else. I want to see the chairs standing in suitable positions, not thrown down or pushed aside anywhere. I want to see the clothes smoothly folded or regularly hanging on their proper hooks. I want, in a word, co-ordination, and I want it all in addition to what satisfies M. Bergson, and when I do not find it I say there is confusion.

The third head under which we have to consider objections to our arguments is that of objections to their result. This is said to be unsatisfactory and inadequate. The idea of God to which it conducts us is rejected as mean and unworthy. Other objections come from those who profess that they are unable to discover anything about God ; these objections come from those who know so much about Him that they think that our result invalidates our argument. If it is contended that to ascribe planning, design and contrivance to God is unworthy of Him because it implies that He is subject to limitation and imperfection; we answer that to think of God at all is to think of Him as limited, and to think of Him as manifesting Himself in Nature is to think of Him as submitting to limitation. Even to ascribe an attribute to God is to assert a limitation, for every attribute which asserts anything as decidedly excludes something else. If we insist on calling God the unlimited or absolute Being we exclude Him from our thoughts and lives, and this absurd result follows, that in trying to ascribe to Him unlimited power we only succeed in denying to Him the power to manifest Himself in Nature or to make Himself known to such creatures as ourselves.

This absurdity lies at the base of the charge of anthropomorphism so often brought against our enquiry and its results. If we are to think of God at all we must think of Him as manifesting Himself in Nature, and we must ascribe the reasonableness of our reason to Him. As there is, and can be, only one reason, the reason that we find in ourselves, we must also think of it as God's. If this is a limitation, and no doubt it is, it is a limitation necessary to thought. If we do not ascribe reason to God neither can we ascribe to Him consciousness nor indeed anything else. In trying to make Him greater than everything we end in making Him nothing.

It is with greater show of reason made an objection to our argument that it leads us to ascribe to the Almighty not merely such limitation or imperfection as may be implied in our being able to think of Him at all, but even such weakness and failure as are only worthy of beings like ourselves. Many of the natural organisms which we have to account for show very decided imperfections; some of them look like failures. Are we to ascribe all these to God as their immediate author and designer? There is no reason why we should do so. Our argument is not really open to this objection. We may suppose that the Almighty entrusted this work to created beings. We may see in the course of evolution the marks of the ministry of angels, and regard many of the forms which are now extinct as experiments which were only partially successful but which showed the way to better things. The flying reptiles which once had possession of the air may have been one of these experiments which had to give way to the better design of the present race of birds. To those who believe that the salvation of human souls is a work which is really entrusted to human beings it is not hard to imagine that other reasonable created beings might have been put in charge of the shaping of the bodies of animals and plants.

The idea of the use of angels or other subordinate agents in carrying out the work of creating and developing the world may also help us to meet the difficulties of those who cannot admit that Nature testifies to the existence of God, because they do not see in it the marks of perfect goodness and benevolence which they would expect to find. The employment of such beings as we are, or might become, in regulating the world may entail imperfections of this kind also. What seems to be hardness or even cruelty in Nature may not really be anything of the sort, but only the result of a limited view which, while providing for one desirable end, fails to combine it with the attainment of another, or even lets the other drop for the time altogether out of sight, and, as we have remarked, the fact that human beings are entrusted with important functions and that they discharge them all in this imperfect way deprives the suggestion of any appearance of incredibility.

It is not of course anything more than a mere suggestion. I do not mean to defend it as a theory of Evolution, I only put it forward to show that we may set aside distracting objections and difficulties and concentrate our attention on the one point which is of real importance. What I have tried to do in this argument is to show that we are justified in taking one step towards God. It is only a short step, but then its importance does not depend on its length but on its being a first step, and making those which come after it comparatively easy. When we come to see plainly that Nature is not self-sufficing and self-explanatory but that it points to an intelligence above itself we have made a real beginning. We have entered on a path that may lead us to the best and highest knowledge that can be attained.

I have made these remarks for the sake of those to whom Natural Theology is really likely to be a first step on the way to the knowledge of God, because it is from such persons that difficulties and objections are most likely to emanate, but this is not my own way of looking at these things. To me the marks of design in Nature are not suggestive of doubts or difficulties, nor do they lead my thoughts to dwell on subordinate agents to whom faults and imperfections may be ascribed. They seem to me rather to resemble the footsteps of my Friend and the sound of His voice, which do not tell me much about His character but are nevertheless welcome as a sign that He is near. It is not I who take a step towards God, it is He who comes to me. And no doubt to many seekers after truth the details of our subject may come in both at the beginning and at the end of their enquiry and fulfil a double function, at the first with the coldness of intellectual light enabling them to believe in the existence of God, at the last with the warmth of devotional fervour assisting them to realise His presence.

INDEX

Aberration, chromatic, 159; spherical, 161
Abstract and concrete forms of argument, 27
Adjustments in plan of Sun-dew, 192
Adjustments, ten in *Orchis mascula*, 144
Aeroplane, the, 211
Allen, Grant, 132, 133, 136
Ammophila Hirsuta, 257
Anthophora, 254
Anthropomorphism, 239, 279
Ants, intelligence of, overrated, 253; leaf-cutting, 259
Arbitrary combinations of chance and order, 114
Archæopteryx, 197
Architecture, Gothic, its *élan*, 73
Argument from order, 103; M. Bergson's, no explanation, 74
Aristolochia Clematitis, 138
Arrangements, orderly, 105
Arum, 132
Atta, 259
Attributes necessarily limitations, 278
Avebury, Lord, 253

Barbicels, 206
Barbs (of feather), 205
Barbules, 206; numerous, 207
Bats, 195
Beating of bird's heart, 203
Bees, instinct of, 253
Belief, a fundamental, 65
Beliefs, primary, cannot be proved, 269
Bembex, 258
Bergson, M., 60; his description of life, 62; his theory of intellect, 62; his account of instinct, 256; his denial of disorder, 276; his theory applied to flight, 217
Bridgwater Treatises, 26

Calculable chance series, 96
Calculation, not of chance but order, 99; of chances, what it presupposes, 44
Calla-lily, 137
Cambridge Natural History, The, 254, 255, 256, 258, 260
Camera, pin-hole, 155
Caudicle, 147
Causal series in contact, 125
Causality, principle of, 6
Cause, distinctions as to, 228; first not an event, 269
Cephalopoda, 219
Chance, defined, 7, 10, 47, 91, 95; theory of, 95, 96; what it can do, 52
Chance, limited, 97; illustrated by dice-throwing, 96
Chance, pure, 56, 101
Chance series, its law and what it can produce, 117
Chance variation, 43; how supposed to work, 58
Chance variations, 48; limitation of, 50; as accounting for eye of plaice, 246
Chance-with-order, 50; three ways of considering, 113; series, how constructed, 118; in Nature, 126

Chances, when calculable, 52; equal, definition of, 116

Changes, different kinds of, to be distinguished, 56

Chaos, M. Bergson's idea of, 277

Characters, Mendelian, 76

Choroid coat of eye, 164

Chromatic aberration, how corrected, 159

Colours, prismatic, 158

Combinations, infinity of, makes a cycle impossible, 124

Common sense, criticised, 6; argument basis of, 60

Contrivance, remarkable and impressive in eye, 167

Convincing power of experiment, viii, 107

Co-ordination, absence of, is confusion, 93; its presence requires foresight, 94; in a plant, 135

Cornea, 163

Correlation, distinctions as to, 226

Creative Evolution, 65, 67, 69, 70, 71, 226, 256

Cross-fertilisation, 132

Cumulative argument, 196

Cumulative effect of examples, 131

Curve, mathematical equation for, 67

Cycle, how formed and used, 123

Darwin, 42, 53; his language as implying design, 143

Darwinian theory, the truth in, 52

Degeneration a difficulty for M. Bergson, 238

Density, varying, of crystalline lens, 162

Desert, characters of plants of, 185

Design, defined, 8; repeated, 140; as construction of order, 30; how excluded from chance series, 119; additional on same footing as original, 56; in cuckoo-pint, 135; may it be ascribed to God? 278

De Vries' observations, why of interest, 84; applied to pecten's eye, 225

Dice, show more design than chance, 97; throwing, an instance of limited chance, 96; why any throw will come at last, 111

Dictionary of Birds, Newton's, 210, 213

Difficulties, keys to truths, 153

Digestion by Sun-dew, 187

Disorder, what it means, 277; its existence denied, 275; may be continued by necessity, 92

Dispersion, 158

Distinctness of vision limited, 172; why, 173

Dominant and recessive characters, 76

Double sight from two eyes, 178

Drosera rotundifolia, 187

Eimer, his theory, 228

Elaborate mechanism of eye an argument, 179

Euler, his happy thought, 159

Evening Primrose, 83

Events, connected and unconnected, 58

Everything is bound to come at last, why not true, 109

Evolution, a happy discovery, 270; of design, 55; a parable of, 262; different kinds of, 31; doctrine of now established, 55, 197; illustrated, 28; of animals like evolution of fire-arms, 33; three doctrines of, 35

Existence, the whole of, reasonable, 269

Experiment, an interesting, 107

Explanation and law contrasted, 273

Eye, the, not moulded, 70; two parts of, 153

Eye, pecten's, as an act of vision, 235; as a casting, 237; details of, 221; compared with mammalian eye, 223

Fairy, a counting, 110
Feathers, uses of, 204; parts of, 204
Fertilisation of Orchids, by Charles Darwin, 143
Flat-fish, plaice a typical, 242; its life history, 245
Flight, power of, how often evolved, 195; three kinds of, 209
Flying-fish, 195
Focus, of eye, how adjusted, 166
Force, its essence, 90
Foresight and purpose produce order, 8
Foresight, the cause of order, 108
Formation, human and natural, 240
Formulæ, Mendelian, 80, 82
Function implies design, 11
Fungus cultivated by ants, 260

Ganglionic cells in retina, 170
Gasteropoda, 219
Giraffe's neck, Lamarck's account of, 42
Glands of Sun-dew, 187
Glass, two kinds of, 160

Heart, reptilian, 201
Heredity, 43
Hilversum, 83
Hunting, how the eye works in, 175
Hybrids, their characters, 78

Idea, the, regarded, as carrying itself out, 71
Ignorance, what kind of, compatible with our argument, 14, 15
Image, inverted, 156; reversed, 176
Images, how formed, 154
Imagination, scientific use of, 182
Imperfection, compatible with design, 14
Imperfections in Nature, 279
Impetus, distinctions as to, 233
Indian corn, results of crossing, 76
Infinitesimal irregularities disregarded, 106
Infinities of chances, 104
Infinity of trials, when it makes no difference, 112
Insectivorous Plants, by Charles Darwin, 187
Instinct defined, 253
Intellect, human, its powers, 267; for what it is required, 62
Intelligence, degree of, needed for evolution, 193
Intelligence, necessity for, evaded, 69
Iris, 164

Lamarckian theory, 38
Lamellibranchia, 219
Larval plaice, its strange way of swimming, 249
Law, no explanation, 272; what it amounts to, 273
Lens, 156; crystalline, 165
Letters, box of, 103
Levels, surveyor's have reversing telescopes, 177
Life, *élan* of, 72
Life as a current, 231; as a beneficent fluid, 232; as an original impetus, 233; an examination, 4; the battle of, 44; M. Bergson's, an abstraction, 64
Limitation of chance by design, 98
Limited chance, 97; examples of, 108
L.M.B.C. Memoirs, No. VIII., The Plaice, 243
L.M.B.C. Memoirs, No. XVII., The Pecten, 222
Loaded dice not a type of design, 113

Logic of Chance, Venn's, 96
Lower and higher order, 102

Machine and organism, 241
Machines and organisms compared, 18, 46
Mammals, their eyes, 152
Marsh-calla, 137
Marsh plants, their character, 185
Mathematician, an infinite, 90
Matter, its essence, 90
Mechanism, its effect due to its designer, 19
Mendel and de Vries, consequences of their discoveries, 75
Mendel, Gregor Johann, 75; his method, 76
Mendelian diagrams, 77, 78, 79, 80
Midges in prison, 134
Miracle defined, 275
Mixed series, 113; in Nature, 126
Moon, eclipses of, a necessary series, 123
Movement, M. Bergson's analysis of, 66
Museum of fire-arms shows evolutionary progress, 33
Mutations, 83; de Vries' theory of, 85

Natural classes, their boundaries not clear, 251
Natural law, 272
Natural Selection, theory of, 42; as preventing evolution, 180
Natural Theology, Paley's, v, 26
Naturalist in Nicaragua, The, 259
Nature, not made and abandoned, 271; its testimony to its Divine Author, 56
Necessary series in Nature, 123
Necessity, can it produce order, 92; as based on causality, 89
Neo-Lamarckism, 229
Number, infinite, a useful idea, 110

Obliquus, superior and inferior muscles, 167
Œnothera Lamarckiana, 83
Orchis mascula, 143
Order, apparently produced by chance, 107; cannot be got rid of, 102; degrees of, 102; M. Bergson's two kinds of, 276; original and added, 122; theory of chance based on, 96; why any instance not used, 121
Order and design, 6
Order and disorder in letter cards, 104
Orderly arrangements most numerous, 106
Organ, as identified with act, 65
Organism, complicated, its origin and meaning, 180
Organisms, infinite complexity of, 57
Origin of Species, by Charles Darwin, 33; its publication and influence, v

Paley, 12; his limitations, 270
Paley's argument, how far undisputed, 21; incomplete, 18; its weak point, viii; to be restated, vi; where it is supposed to break down, 21
Paley's two examinations of the watch, 24; a third necessary, 27
Parable of the harbourmaster, 180
Passage from disorder to disorder may be calculable, 92
Pecten, maximus and *P. opercularis*, their shells, 220
Perceiving differs from seeing, 174, 179
Philosophers, how they deny obvious truths, 61
Philosophies, how they decay, 61
Philosophy, its aim, 60
Physical causation, what it can do, 93

Plaice, larval, its strange way of swimming, 249
Plan, a change of, 142
Plant Life, by Grant Allen, 133
Plants, how affected by changed environment, 183
Pollen, how arranged in *Orchis mascula*, 147
Pollinium, 148; removed, 149
Possibilities not existences, 68
Postulate on which action depends, 16; on which reasoning depends, 16
Presuppositions to be avoided, 274
Principles, first, what they are, 269
Prism, 157
Production of an infinite number, 110
Pronuba synthetica, 255
Proof by experiment, 107
Properties of chance series, 117
Providence defined, 275
Pure chance, 101

Question, the great, 3

Reason, only one, 279
Reason why chance cannot produce order, 108
Recent Progress in the Study of Variation, Heredity and Evolution, 82, 84
Relation of orderly to disorderly arrangements, 106
Repetition, 107
Reptiles, characteristics of, 200; flying, regarded as an experiment, 279
Reptilian features in early birds, 198
Response to change not result of change, 184
Retina, 165, 168; small thickness of, 168
Reversed image in eye, 176
Rods and cones of retina, 170
Rostellum, 147
Rozites gongylaphora, 260
Rules of the game exclude infinite chances, 98

Salt places, characters of plants of, 185
Satisfaction gained by the actual experiment, 107
Science, its limits, 91
Sclerotic coat of eye, 162
Sculptor, blindfolded, 58
Seeing things as they are, what it means, 177
Selection, human, limits of, 53; Natural, may produce new species, 54, 55; of chance variations, 127
Sitaris humeralis, 254
Snail's horns, Lamarck's account of, 42
Soaring, difficulty of understanding, 214
Species, Linnæus' and Jordan's, 84
Spelling game utilised, 103
Sphex, 256
Sphinx, the, as a rock worn down by chance, 57
Sports, 51
Square of an infinite series, 111
Step, a considerable, must often be made at once, 186; the first is most important, 280
Structure animal adapted, 197
Subordinate agents in creation, 280
Succession of organisms considered, 22
Sun-dew, 187; its digestion, 190
Survival of the fittest, 43
Sweet-sedge, 137
Swimming powers of pecten, 221
Symmetry, 107

Table of sixteen squares, 80, 82
Target practice combines chance and design, 51

Telescope, astronomical reverses, 177
Test, a crucial, 107
Things actual and possible, their numbers, 111
Trap for fertilising insects, 139
Trials, infinity of, may make no difference, 112
True breeding of de Vries' mutations, 85
Twist in flower to be accounted for, 146
Twist of plaice's skull, 244
Typhon, his story, 262

Unequal chances, how to be dealt with, 115
Uniformity and variety in chance results, 116
Universe not self-contained and self-sufficing, 270

Value of concrete illustration, 27
Vanessa levana and *V. prorsa*, 228
Variations, heritability of acquired, 230
Vision, centre of, 172

Wallace, Alfred Russel, 42, 153
Warm blood, how maintained, 201
Wasps Social and Solitary, by George W. Peckham and Elizabeth G. Peckham, 257
Watch, Paley's, 12
Weather, why it cannot be predicted, 124
Weather when regarded as chance, 49
What we see, 174
Wing, bones of, 208 ; formation of, 209
Wings, bat's and reptile's, 195
Wings, broad and narrow, 214
Workman and work, relation of, not degrading, 193
Works of art and works of Nature, 16
Worship, indivisible act of, 73

Yucca moth, 255

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